Groundwater Problems and Prospects_3_2_2015

cjbowman@ucdavis.edu

[background conversation]

0:00:05 Rick Frank: Alright, good afternoon. I see some unfamiliar faces in here, so I'll briefly introduce myself. I'm Rick Frank. I'm a professor here at the law school, and one of the three instructors of this course, along with Thomas Harter from whom we'll be hearing later again in this afternoon's class' session. Today we're going to talk about groundwater-dependent ecosystems, and talk about something that the hydrologists certainly know already, and that is, even though we've been talking about groundwater for the last seven weeks in the class sessions, it's difficult, but not impossible, as a matter of hydrology at least, to talk about groundwater in isolation, because there are some significant lengths to surface water flows and supplies, which is very interesting, because the scientists and the engineers know that, but our legal system continues, for the most part, to think of groundwater and surface water sources as distinct entities, and treat them differently. The 2014 Groundwater Legislation made some very modest inroads into that disconnect, if you will.

0:01:28 RF: At several points in that legislation, there are references to the inter-plan activity, I'll then do some groundwater and surface water systems. So that's what we're going to discuss this afternoon. And as I mentioned last week, we are taking the subject somewhat out of order. On our syllabus, we show this subject as originally having been scheduled for our last class session on Monday, March 16th, but to resolve some scheduling issues that arose, we decided to handle that topic class session today. And we have flipped that with the topic that was originally going to be on the agenda for today, but now will be covered on that last class session on March 16th, that topic being "Integrated Modeling with Groundwater Sustainability Planning." Another key issue, and we'll be joined on that issue in two weeks from today, from experts from the California Department of Water Resources, as well as the US Geological Survey.

0:02:29 RF: So while two-thirds of today's class sessions is gonna be presented by your co-faculty members, we're honoured to be joined today by a guest speaker, who will be our lead-off speaker, and that's Maurice Hall. Maurice, as of a week or two ago, is the Water Program Director for the Water Funders Initiative, which is a collaborative effort to identify and track funding for the most promising solutions for the problems of water scarcity and reliability in the United States, with at least an initial focus on the American West. Until a couple weeks ago, and since 2008, Maurice worked for the Nature Conservancy here in California, where he eventually served as the science and engineering lead for TNC's California Water Program. There he was responsible for the hydrologic science and engineering program, underlying the Nature Conservancy's water strategies in California. Critically,

and relevant to this course, Maurice's work at TNC included leading the conservancy's efforts to shape and help pass California's landmark 2014 groundwater legislation.

0:03:38 RF: His tactical backgrounds in hydrology and water resource engineering. Before joining TNC in 2008, he practised for more than 12 years as a scientist, engineering and project manager, both in a consultant capacity, and as an employee at the California Department of Water Resources. Before that, he's truly a Renaissance man, he was an assistant professor of Engineering Geology at Radford University in Virginia, where he taught courses in watershed management, water quality and groundwater modeling. Maurice received his Bachelor of Science in Chemical Engineering from the University of Tennessee at Chattanooga, and his PHD in Hydrology from Colorado State University. He's a registered professional civil engineer in California. And I'll finally say that I first heard what I think is going to be a version of the presentation Maurice is going to give today at the Yosemite Environmental Law Conference last October, and we thought it would be great to have him customize that talk, and present it here to talk conceptionally about the connectivity issues of groundwater and surface water, after which Thomas Harter, and I will talk about a more specific case study. So, Maurice.

0:04:54 Maurice Hall: Thank you very much. It's a delight to be here, and with respect the groundwater in California, it's a very, very interesting time, as I'm sure you are learning. I as Rick just mentioned, I was at the Nature Conservancy for seven years, and I actually presented a couple of weeks ago to the Nature Conservancy's California Board. And, my presentation was about the groundwater legislation and I said, "Seven years ago, I was interviewing for the job, and I was asked in my interview, 'What's the biggest challenge that we have to face in California, or deal with in California with respect to water?' And my answer was, 'We have to somehow get a hand on groundwater management, otherwise we're trying to do everything we're doing with a leaky system.'" And so, the Groundwater Legislation was something I've been working towards for a long time to try and insert information specifically about this issue of how it's not just about the groundwater, but it's about how groundwater management or the lack of management impacts and undermines the surface water supplies.

0:06:09 MH: You've probably heard quotes or tidbits, factoids about groundwater being about a third of our water supply, and surface water being the rest of it. But in fact, groundwater is even more important than that because it does underlie and at times certainly supplies part of the surface water, and in pumped groundwater, it affects the surface water, and I'm going to talk a little more about that in detail. So I'm titling my talk "Groundwater/ Surface Water interaction and the Status of that Connection in the California Central Valley," because we, at the Nature Conservancy, did some work to really try and illuminate the issue in the Central Valley. So I'll talk with you a little bit about that just to give you a sense of how big a deal it is with respect

to surface water.

0:07:01 MH: Just a real quick overview. I know in your first class, I think you had some discussion with Graham Fogg about groundwater geology and hydro-geology in general, but I'm going to brush over a few of these things just to give you a reminder of the setting that we're talking about. Mostly when we talk about groundwater in California we're talking about these Valley field aquifers which are basically any flat place in California. It's probably... You're standing on a Valley field aquifer if you're standing on a flat place in California in Central Valley, the Napa Valley, Santa Clara Valley down south, the LA Basin, those are Valley field aquifers where sediment is filled in between surrounding hills, and most of those have some water in them. And, in fact, in California, most of the time that water is usable.

0:07:50 MH: And this map shows the Valley field aquifers that are officially delineated by the California Department of Water Resources, and this represents 90% or more, probably 99% of our ground waters pumped from these basins. Sometimes we have basins and sometimes we have sub-basins. Sometimes the delineations between the basins that make the sub-basins really are meaningful and sometimes they're really not very meaningful. But in the Central Valley that's particularly the case in that there's no hard boundaries between the sub-basins. Just to give you a brief input, a brief overview of the water use in California and how much of it is groundwater, this is from the California Department of Water Resources Water Plan. And the tall bars show the total water use in that region. The state's divided into these 11 hydrologic regions.

0:08:53 MH: And so when you have a really tall bar that means that the total water use there is really big. And this smaller bar represents the fraction of that, or the portion of that, that is supplied directly by groundwater, so that just means it's, what's pumped out of a well. And you'll see that in the Central Valley, you have a huge amount of water use. And in the northern part of the Central Valley a smaller fraction of that is groundwater. In the southern part of the Central Valley down in the Tulare Lake basin, this is basically Fresno South, Fresno and Bakersfield. A much bigger percentage of the total water use comes from groundwater.

0:09:31 MH: Now there's much less water use in other parts of the state but you might notice, for instance here in the Central Coast, that much smaller amount of total water use, but nearly all of it is groundwater. And part of the reason for that is that there is very little reliable surface water flows, reliable flows in rivers and streams there and so long ago we turned to groundwater as the main water source in those regions. Well there's a total of about 15 million acre feet of ground waters pumped in California. A million acre feet that will provide water to about two million households, is that right? And so that's a huge amount of water. I've heard it said that California pumps more groundwater in a year than all of the rest of the nation combined. I haven't

seen the original source of that, so I'm a little sceptical about that, but we definitely pump a huge amount of groundwater and most of it is here in this Central Valley. And 80% of Californians rely on groundwater for a part of their water source.

0:10:46 MH: So I'm going to first talk briefly about groundwater overdraft in the Central Valley. You've probably heard some... Almost certainly heard some discussion about this. Groundwater overdraft basically means you're taking more water out of the groundwater basin than is being recharged. And this comes from some work that we did, actually using the Department of Water Resources Integrated Groundwater and Surface Water Model in the Central Valley. So this is a model that's accessible to anyone, it's been developed previously, but it really represents our best picture of the total water use and how the groundwater and surface water are interacting in the Central Valley.

0:11:25 MH: There is another model that USGS has built, the Central Valley Hydrologic Model that will basically tell you very much the same thing, they're a little bit different here and there in how the geology is characterized and how the water uses are estimated and that sort of thing, but this represents a pretty good overall picture of what's going on in the Central Valley. What these lines show is the narrower lines are annual pumping amounts, and they go up and down. Wet years, you pump a lot more, dry year, you don't pump as much. And there are three different regions, the San Joaquin, or the southern San Joaquin, or Tulare Lake basin is this green line. The heavier lines represent 10-year moving averages, so that just smooths out all the noise and shows you what the trend of groundwater levels are. In this case, it is in terms of the amount of water that's stored in the groundwater. So this trend down means that more water overall has been taken out than is being recharged. And in the case of the Tulare Lake basin, to the tune of something like more than a million acre feet more water has been drawn out of, more than 100 million acre feet, more water has been drawn out through the years than has been recharged.

0:12:42 MH: The other parts of the basins... The San Joaquin, it is not quite as dramatic, something like 20 million acre feet over the last century. And this yellow line represents the Sacramento Valley, which most folks think of as being reasonably healthy. The groundwater levels aren't plummeting like they have in other parts of the Central Valley, but in fact, the groundwater levels have declined through time and it's had some pretty significant impact to with respect to surface water that I'll describe to you in just a little bit. This is just another way of looking at the Central Valley information. This came from the same model, but it just plots how far the groundwater levels have gone down through time between 1925 and 2009. This is one level, this is the top level of the aquifer, and this is the bottom level of the aquifer. And the reddish areas on here show the areas where the groundwater levels have gone down several hundred feet, and there are places where the groundwater levels are more than 500 feet lower now than they were in the 1920s and '30s.

0:13:45 MH: So this is just evidence of the huge amount of pumping, the overdraft, and the long term downward trend of water levels. Now I'm gonna switch in and talk about this groundwater/surface water connection that is the main topic of our work today. This is a picture of the Cosumnes River, which is a small river in southern Sacramento County, that flows year-round out of the mountains. And once it gets out on the Valley floor, it flows over this big Central Valley alluvial aquifer. It's a big flat Valley, so there's probably groundwater under it. And in fact the groundwater levels have been drawn down under the Cosumnes River to the point where now every year, all of the water that flows out of the mountains sinks into the ground beginning about July 4th or so, the Cosumnes River goes dry in the lower 10 or 15 miles. And it stays dry well into the fall because those groundwater levels have been drawn down.

0:14:40 MH: So anytime you see a river like this, flowing over a flat valley in California, think about what's underneath. There's almost certain to be groundwater underneath under some condition. In a natural state, before we pump and we lower the water levels, the groundwater tended to flow out into the rivers because that was the lowest point, so the basin basically filled up until it got full enough to start oozing out, and it oozed out at the lowest points along the streams. So under natural conditions without pumping the groundwater, most streams tend to gain water from the groundwater. That's really the only reason we have stream flows unless there's a dam upstream. The only reason we have stream flows likely here is because the groundwater is oozing out of the ground into the stream and contributing to stream flow.

0:15:35 MH: Now when we pump wells, we basically lower the water level from the wells. That lowers the water levels in the surrounding areas. If you have a lot of different wells, you can lower the water levels over miles and miles and miles of aquifer, and that is what's happened in the Central Valley. When you do that and the groundwater levels in the surrounding areas are lower than the stream, the stream loses water to the groundwater. The water flows downhill even in the ground. And so in this case, this illustrates that this stream is losing water to the groundwater, and conversely, the groundwater is being recharged by leakage from the stream. And this happens all up and down the Central Valley, and it happens in the Salinas Valley and it happens in the Santa Clara Valley where streams are flowing over the surface and there's a fair bit of groundwater pumping, recharge from stream leakage is an important source of the recharge that keeps the aquifer levels from going down faster than they would otherwise.

0:16:35 MH: Certainly, you can get to a point where you draw the groundwater levels down and at this point it becomes what we call 'disconnected from the stream'. And when it gets disconnected, it doesn't matter how much further you draw the groundwater level down. The stream's just gonna leak as fast as it can leak through the sediments. And this is a

situation that we have in a good bit of the Central Valley, particularly down in the southern part of the Central Valley. Then the stream will go dry if the leakage rate exceeds the flow, so if the flows get low during the summer and the stream doesn't have a lot of flow in it, it will leak into the ground. So this is basically how the groundwater/surface water interaction works. When you have streams flowing over these alluvial aquifers.

0:17:25 MH: So I mentioned before, the groundwater level differences through time in the Central Valley, and this just re-highlights that same figure. And in the southern part down here, you see that groundwater levels have been drawn down a couple hundred, 300 feet. And so most of the streams in this region, once they get a little bit of way out of the mountains, even down here these streams flow year round out of the mountains often because they're supplemented because of reservoir releases, but the streams flow out of the mountain. But once you get a little ways out on the Valley floor, those spring beds are dry and almost never flood: The Kings River, the Kern River. Out on the valley floor, there's infrequently you have storms, and a lot of flow that most of the time those river beds are dry and they are in a condition very much like this.

0:18:22 MH: Further north in the Central Valley, we have a lot of streams that are still connected to the groundwater and it's those that I want to talk about next, because this is really the key point and the real... The fundamental reason that I was so adamant in the groundwater legislation that we not ignore the interaction between surface water and groundwater. So what's happening here is basically, let's assume you have a groundwater basin, and this is represented in a lot of different places in the Sacramento Valley, the wetter part of the Central Valley, where you've had pumping for a long period of time and you've had an equilibrium established. So the recharge equals the pumping rates, and so the groundwater levels aren't going down any further. And part of the reason that you can pump some groundwater out and not continue to lower the groundwater, is that the river leaks and recharges the groundwater.

0:19:18 MH: So, let's assume that this is the case for a number of years and then we increase the pumping and put some more wells in, and we draw out more groundwater. It lowers the groundwater levels for a while so for a little while you're in overdraft condition, you're drawing out more water than is being recharged but, what happens in this case when you still have a connected river, you have a steeper gradient, groundwater gradient away from the stream and so the stream leaks more and it contributes more recharge, and so you could in fact imagine that even with this increased pumping, after a little while, a new equilibrium is established that does have more recharge now supplementing that groundwater and replacing the water that's withdrawn.

0:20:08 MH: But that comes at an expense. It's not new water that's

magically formed. It's water that's being taken out of the river and these rivers and streams are somebody's water supply. They may be water supplies for fish and wildlife, but they're also the water supplies for the City of Sacramento perhaps, and the export pumps that take water to Southern California and the state and federal water projects, and were needed for some delta outflow to try and protect endangered species in the delta. And so, when you increase this pumping and draw the groundwater levels down, you draw in more water from the surface flows, and that means that there's less flow in the streams. And once again if you draw it down further, you also have issues with wells going dry when you lower the water levels. You draw it down further and the stream is still connected, you further increase the rate at which the stream leads its flow to the river.

0:21:10 MH: So, this is a really important deal, not just for groundwater management, but for the reliability of our surface flows. And so, you might ask how big a deal is it? Well, we did some work with this same model to estimate how much water... How much a difference does it make in the Sacramento Valley 'cause Sacramento is really our biggest source of freshwater supply in the state. It's the main source for the Central Valley project and the state water project that supplies part of Southern California, so if it's affecting Sacramento, there's a lot of people who'd care. And so this plot shows the net stream gain and loss for the Sacramento Valley. So some cases you have stream reaches and the alluvial aquifers are losing water to the groundwater. In some cases you have, because recharge is high in areas, you have reaches of the stream that are gaining water. So this plot shows on the whole, for the Sacramento River and all of its tributaries, how much water was the Sacramento in the valley floor once it leaves then, gaining or losing to the groundwater.

0:22:25 MH: Now this tipping point... You may have heard some people talking about the tipping point. The tipping point is where the river becomes a net zero; it's losing as much to the groundwater as it is gaining from the groundwater, and we think that that happened with the Sacramento River probably in the last 15 years or so. So back in the 1950s and '60s, the Sacramento River... This is downstream of all the dams. This is in the valley floor. The Sacramento was probably gaining, Sacramento's tributaries, was probably gaining about a million acre feet per year on average from the groundwater. So that means in addition to the water that was released from the reservoirs or that flowed out of the side stream, another million acre feet per year was contributed to the flow of Sacramento by groundwater pumping, by groundwater inflows to the river.

0:23:15 MH: But as pumping progressed through the years, the groundwater levels were drawn down. You remember that earlier plot? They weren't really drawn down a lot. They were drawn down some. And so overall, it reduced the amount of water that was flowing from the groundwater into the Sacramento River tributaries, to the point where, around now, this was 2009 was when this

model ended, around now, we're pretty much at a net-zero. So that means a million acre feet per year on average, somewhere around there, maybe it was 700,000, maybe it was at 1.4 million, but a pretty good bit of water. There's less water in the river than there would have been without groundwater pumping. Now, a real interesting thing that we also learned is that we tried to model into the future by keeping the same rates of pumping as we have today...

0:24:07 MH: Not increasing pumping... But just the same rates of pumping as we have today. And other conditions kept about the same... Reservoir operations, releases, and the way that we manage the water. And in fact, the impact from the pumping that is occurring today hasn't reached the river yet. And so, 10, 15, 20 years from now, there's going to be even less flow in the Sacramento River than there would have been because of the pumping that's happening today. You've probably heard from Dr. Fog earlier about the groundwater hydrology and how groundwater takes a while for the impacts to move through the aquifer. And that's really the case here is that the impacts from today's pumping haven't even shown up yet in the river.

0:24:53 MH: So, something like 900,000... Close to a million acre feet... Less water shows up in the Sacramento on average in a year than it did before pumping, and we expect that erosion to continue to the tune of something like 400,000 or another half million acre feet at today's level of pumping. Today's level of pumping is not reality anymore. This model stopped in 2009. There's estimates that say something like 200,000 new acres of land in the Sacramento Valley or for Sacramento, have been brought under irrigation since 2009. New orchards primarily, olives and almonds... And so not just today's pumping, but that increased pumping is going to take years and perhaps even decades to show up at the river.

0:25:54 MH: So, this is why in a really big way... And it takes the Sacramento River, a really important water supply for a lot of different people and a lot of different wildlife, is really important to manage groundwater to avoid, as the legislation describes, "The undesirable result of significant impacts to surface flows and beneficial uses of surface flows." It's the same language. Because if we don't pay attention, and we don't implement good river groundwater management, then the groundwater pumpers basically end up having the Senior Service Water Act. Pump the groundwater, you can draw it out, and you are going to basically be... It's going to be reflected in the [0:26:38] ____ in the surface water.

0:26:42 MH: Now, this is the same plot for the other parts of the Central Valley. It's not that dramatic. Just basically the same condition that has happened with a tipping point in the Sacramento River happened many years ago in the Tulare Basin in the San Joaquin forest into the Central Valley. I'm going to switch just a little bit now and talk just briefly about some other groundwater-dependent ecosystems. What I've been talking about so far has

been this groundwater-dependent ecosystem... Those who depend on the stream flows. And we're going to hear in just a moment about a specific situation in the Scott River where those groundwater-dependent ecosystems have been compromised by groundwater pumping. Or at least I think that's what the story is going to be.

0:27:39 MH: But we also have other groundwater-dependent ecosystems, and these are things like... We have the vegetation and forest, forests and trees that can access the groundwater... Their roots go deep enough to be able to access the shallow groundwater. You have places where local lenses of groundwater called " perched level groundwater"... That Dr. Fogg may have mentioned to you... That support unique habitats and these habitats depend on certain groundwater conditions. And down here we have riparian vegetation. This is on the flood plains where you have wetland habitats, and one of the reasons these habitats developed is because there's high groundwater levels all the time. And so the vegetation that can depend on that water and need that water all the time, can survive in these areas but they can't survive further up the slope further away from the groundwater.

0:28:33 MH: So, these are groundwater-dependent ecosystems and the Nature Conservancy did some really interesting work to try and map where these occur across the state. And this is from a report published in Plus One by Jeanette Howard, it's one of my colleagues there at the Nature Conservancy, and Matt Mayfield. Mapping, in this case, groundwater-dependent wetlands. So, in addition to the streams that are groundwater-dependent, these are wetlands that have special groundwater level needs. And one of the things required in the legislation is that groundwater management consider the impacts to groundwater-dependent ecosystems. And so one of the things that we want to provide, or the Nature Conservancy wants to provide is better information on how to assess these. And so, one of the conceptual ideas here is just to illustrate the importance of it, is to take that groundwater map of, that map of the groundwater basin and, in this case, color it, or shade it in according to the density of groundwater-dependent wetlands.

0:29:40 MH: How many acres of wetlands per square mile of groundwater basin are there? And you can see that as you go north, generally, in the state you have more and more groundwater-dependent wetlands. Part of that is because of the geography and the different weather conditions and part of that is groundwater levels have been drawn down in a lot of the parts of the state, so those wetlands no longer exist. So if we want to see these wetlands persisting in the future, we're gonna need to thoughtfully manage the groundwater to prevent them drying out as they have in other parts of the state. They just wanted to show that as an indication that there are other groundwater habitats and natural systems that depend on groundwater besides the streams, and in fact the Nature Conservancy is putting together a nice database that you can access that provides a lot of digital information for spatial analysis of this kind of work, and it's the kind of information that the

Department of Water Resources as they developed the guidance for implementation of groundwater legislation are gonna need to grow on.

0:30:55 MH: So I'll leave you with that. With just a picture of one of the most special groundwater and inland wetlands in my... To me... And this is the Amargosa River down in the, east of Death Valley. The Amargosa, you can see it on a map and it's hundreds of miles long, but it really only flows above the surface for about 15 or 20 miles in a few specific places. The groundwater... At those points the groundwater rises to the surface and supports a year-round stream here where it's 115 every day in the summer. So with that I'll turn it over to my colleague. Thank you.

0:31:33 Thomas Harter: Thank you Maurice.

[background noise]

0:31:49 TH: So I'm going to switch here a little bit, going to the other side of California. The one on the right, and go to the Scott Valley, and if you look at a background on the Scott Valley so that Rick can then talk about why the Scott Valley is so interesting from a eco perspective. Now I wanted to acknowledge... For what I'm showing you today... I wanted to acknowledge Gus, who is in the back, who's working with me on logical modeling that we're doing there, as well as Jacob Newman and Laura Folia, at the University of Darmstadt, who have spent much time on this. So let me give you a little bit of background on Scott Valley, and talk about why Scott Valley is interesting from a groundwater surface water perspective.

0:32:40 TH: Wow, this projector is really bad. I get very different colours on my computer. So let's see what we can do. So Scott Valley is in the far northern California corner, close to the Oregon border. The black rectangle there shows the location, and you can sort of barely see California on the left coast map, the Scott Valley in the lower right you can sort of see it's surrounded by mountains. The watershed is about 800 square miles. The elevation in the Scott Valley ranges from 2,700 feet up in the Northwest corner where the Scott River flows out of the valley, to 8,000 feet in some of the mountains that are just to the west of the valley. And Scott River flows from the south to the north and out to the Northwest along the east side of the valley.

0:33:39 TH: This is an interesting system for California, it's a very shallow alluvial valley, geologically, that's sort of embedded into the mountains, and that is created, essentially because a fault spilled up or dammed up the Scott River up in the Northwest corner there, and allowed the Scott River to basically sediment in the mountains there, and create this aquifer system that's sitting at the floor of the valley which has about 30,000 acres of agriculture. So this is a cross-section of the border part of the valley, and you can see the bedrocks, they're very close to the surface. You have somewhere

between 100 and 400 feet of sand and clay sediment that have been still in here by the rivers that come off of these mountains and sort of fill up this area above the bedrock here and in the bottom of these, what are called 'bathtubs'.

0:34:40 TH: And so you have the aquifer system here containing the sediments here, and the way this works is roughly like this. So again, you get bedrock that's fractured and fallen, and you get the sediment fill that's been deposited by the Scott River in here, and recharge from the rivers that come out of the mountains as Maurice explained, and then recharges that flow into the valley, and recharge for precipitation has filled these sediments with water, and of course as these sediments then are filling up with water where does that water eventually come out? Well, it comes out at the very lowest spot, right? We can all kind of imagine this, if you dig in the sand and there's a river nearby, you dig large enough you can find that groundwater. It's actually sitting in these sediment particles, in the core space of these sediment particles, and as it fills up some more, this water flows to the river as Maurice showed you very nicely. That's what we have in the Scott Valley.

0:35:43 TH: So you have the Scott River flowing through this valley that's about 20 miles long, about three to four miles wide, and early in its history we had gold mining happening, at the southern end of this valley we've had dredge mining going on until about World War II, for gold and silver, and much of the southern most part of this valley is filled with old dredged hills. We have a lot of ranching in and around this valley, and on the valley floor, we grow hay, hay and alfalfa predominantly, and this has been the case for much of the 20th century and even late 19th century. Now, much of this used to be flood irrigated, where river water or canal water is taken and used to flood meadows, either pastures or alfalfa meadows. There is a number of canals that divert water from the Scott River along the side of the valley to then flood meadows and pastures and alfalfa fields. In the...

0:36:52 TH: This is another image of a meadow that's flood irrigated. You can see sheep on this particular meadow. About half of the acreage here is alfalfa, and they harvest fairly high value alfalfa, two to three times per year. This is a map of the land use. Everything that's in yellow here is alfalfa. What is shown in green here is pasture, all of which is irrigated. The blue areas are non-irrigated dry land, farming areas and then down here in brown you can see the dredge tailings from the former mining operations from the 19th and early 20th century.

0:37:39 TH: Then in about the 1960s to 1970s, a significant part of the valley converted from very inefficient flood irrigation, to much more efficient sprinkler irrigation using these wheel lines. Many of you that have been to Oregon or the coast have seen these wheel lines, or elsewhere in the west of the United States. Most of the alfalfa that we grow in the valley became irrigated with sprinklers, and for these sprinklers the farmers turned to wells because they have to be pressurized anyway, and an easy way to pressurize

this line is to do sink the well into the ground aquifer of water into these sprinkler lines. So, with these wells, we're pumping this water table, and from this water table we create what's called depressions in the summer, and in the winter recharge fill [0:38:31] ____. This is kind of going back and forth in the Scott Valley, and these graphs from a number of wells in the Scott Valley that show water levels from January of 2006 on the left side, to January of 2014 here on the right side.

0:38:53 TH: You can see there's annual up and down of water levels that doesn't really change very much over time. Most of these wells seem to be relatively steady, and even though over the last eight years we went through two droughts, the 2007 to 2009 drought, which is sort of in the middle of this graph, and more recently the 2011 to current drought which is on the right hand side of this drought. We really don't see a major impact of that drought on these groundwater levels. What also has happened more recently is that many of these fields that used to be sprinkler irrigated with wheel lines, are now on these large centre pivots which are even more efficient than the sprinkler lines.

0:39:39 TH: This is a map showing in blue where we have centre pivots, in orange where we have wheel lines, that's mostly alfalfa acreage. Then in green this is still flood irrigated area mostly on pasture. What you see here in red are the irrigation wells that have been drilled over the last 40 years, to serve these sprinkler lines here in the Scott Valley. And this is an estimate that we calculated with our PEW models on how much is actually being pumped for these fields from the groundwater system. What you can see is that a lot of the pumping happens relatively close to the Scott River throughout the Scott Valley. So, you may ask, "What's the big deal here? What is the connection to this groundwater dependent ecosystem?

0:40:26 TH: Well, we have the Scott River. The Scott River is one of four tributaries to the Klamath River below Iron Gate Dam. It's one of four rivers that salmon can access as a spawning ground coming from the Pacific Ocean. It's the largest river and the largest one of these. So, the spawning grounds we have both a Coho-run and a Chinook fall run of salmon that are coming up the Scott River in the fall. When flows increase they come up here in the fall, they spawn, the Chinook will leave in the spring, the Coho, the juvenile Coho will stay over the summer and then leave in the following winter. So summer flows are very critical for the Coho, and it's those summer flows that are impacted by the groundwater pumping that we're doing for the irrigation on the alfalfa.

0:41:28 TH: So, we have... What we have seen in... Where much of the conflict in the Scott Valley arises is that the summer flows on the Scott river have been significantly lower in the last 30 to 40 years than what we have seen in the 40s and 50s, and 1960s. And this change in when we are seeing this extremely low summer flows, typically in August and September, really

kind of coincides with the switch from flood irrigation everywhere to having about half of the valley sprinkler irrigated with wheel line sprinklers and now center pivots. One of the older wells that have been monitored for a relatively long period of time by the Department of Water Resources also is showing somewhat lower water levels perhaps reflecting the same phenomenon. Now this is not the one I wanted to show...

0:42:31 TH: So if you look at average annual stream flow on the Scott River, and we look at just the period from May through September which is really the critical low-flow period for the fish, we can see that in the 1940s to the 1960s, that low-flow tended to kind of bottom out at about 60 cfs. If you take the last 20 years, that low-flow tended on average, this is a 20-year average, that low-flow ended up at about half as much or about 30 cfs. So that's a significantly smaller amount of stream flow, and some of that decrease has been explained in a recent paper where statistically this watershed was compared with the other three watersheds that are in the the Klamath Basin, some watersheds in the Klamath Basin that are salmon spawning grounds, about one third of that decrease has been shown to be, or at least one third of the decrease has been shown to be due to climate change. Now one of the interesting aspects of this is actually that the 40's and 50's weren't exactly the driest time of the last century. The 40's and 50's, these earlier records that we have for the Scott Valley, tended to be a relatively wet period.

0:44:06 TH: We've had a lot more dry years in like 70's, and again around 1990 and then of course most of the last 15 years were relatively dry. We've also had a very low flow periods in the 1930's, 1920's and 1930's, these are perhaps for the Sacramento Valley and the San Joaquin Valley showing the droughts in the 1920's, and 1930's and there are in fact newspaper articles that talked about the Scott Valley, the Scott River being completely dry in the late 1920's. So the scene here is really set for conflict between agricultural pumping, the environment where we have the age of species and public trust doctrine, that Greg is going to talk about, the Clean Water Act, and the fisheries. Native Americans use salmon downstream, we have an offshore industry, fishing industry on salmon, and so the Scott River is sort of in the middle of this conflict that we had. The part that we have been contributing to this is that we've been developing modeling tools to better understand the system and the hydrology in the systems, to work with the state over in the Scott Valley and help them understand how the system works and what potential management, groundwater management practices, may actually improve the groundwater close into this, the stream flow situation in the late summer.

0:45:22 TH: So we've put together models that look at the budgets, that look at recharge and pumping and how that pumping is impacted by pumping patterns. We have a 20 year groundwater model that Gus is working on that shows the impacts of both wet years and dry years on the overall budget to different fluxes in Death Valley. One of the things that we're finding is, when

we go at this modeling and use textbook values for irrigation on alfalfa, the irrigation amount that we calculate, which is on the order of 30-40 inches, is actually much higher than what growers report and farm advisors measure for irrigation in the valley, and it turns out that they are actually super efficient in the irrigation of the alfalfa. It's part of the research project, and are finding that they are using much of the soil moisture storage in the valley for their irrigation, which is highest right here along the river.

0:46:22 TH: They actually use soil moisture storage from winter and spring for much of their summer irrigation. We are using this modeling tool, and we'll talk about modeling tools more in two weeks, we're using this modeling tool to essentially look at some of they key alternatives that we have in order to increase stream flow in the summer, we need to have more water in the aquifer in the summer when that base flow happens. And to increase the amount of groundwater storage, one of the alternatives that we're looking at is to actually not start pumping until, and use surface water for irrigation until there is not enough surface water to do that, which would extend the surface water irrigation period into May or June, and would give us several cfs additional stream flows in the summer because of that additional storage happening in the spring.

0:47:20 TH: We are looking at impacts of beaver dams which raise the water level in the aquifer system throughout the valley, and we are looking at recharging in the gulches that are on the east side of the valley that are relatively empty which have... There is usually depths to water table of anywhere between five to 20 feet, recharging these gulches with irrigation water during the winter to then have that flow support summer base flow on the river, and we're finding again that we can get additional flows that are on the border of three to 10 cfs, based on these recharge scenarios. So with that, I'm going to give the microphone to Rick and have Rick talk about what the legal issues are and stuff...

[background noise]

0:48:32 RF: Okay. I'm gonna talk about how the Scott River Valley has evolved or devolved based in large part on the scientific and engineering data that's been compiled by Thomas and others, into what I would characterize as probably one of the biggest and most, currently, heavily publicized pieces of environmental litigation in the state of California. In the interest of full disclosure, I should say at the outset that in addition to teaching here, I am one of the lawyers litigating this case. So, I'm not a detached observer and commentator and one of the attorneys in the litigation, so take what I say with that in mind.

0:49:25 RF: And the ultimate goal of this litigation, which we initiated in 2010 or 2011, is designed to establish the principle that groundwater as a resource is, at least that groundwater that has a demonstrated hydrological

connection to surface waters, surface navigable waters, like the Scott River, are impressed with and subject to the public trust doctrine. For those of you who are not law students, you may or may not know what the public trust doctrine is so, I'm going to spend just a moment talking about that and I should acknowledge early on, that one of the architects of the public trust doctrine has a modern [0:50:09] ____ principle that environmental law is here in our classroom. Harrison "Hap" Dunning, who is a professor emeritus here at UC Davis, was one of the key people who served to make this longstanding principle of, legal principle, of property law that's been around for centuries or millennia, actually, converting it into a principle of modern environmental law.

0:50:34 RF: The public trust doctrine has its origins in Roman Law, in English Common Law, and relevant to California and the American Southwest, Spanish and Mexican law as well. As I say, one of the key principles of the last 50 years of environmental law has been the development or embrace of this long-standing legal doctrine as a principle of environmental law. Volumes have been written, literally have been written about the public trust Doctrine. What I've tried to do here is distil the key concept or concepts into one PowerPoint slide.

0:51:09 RF: So what the public trust Doctrine at its essence provides, is that certain natural resources are incapable of private ownership, but are instead held in trust by the Government for the benefit of current and future generations. And beyond that, a second key principle is that government managers of these public trust resources, known as trustees, have not only the power but have the obligation, the legal obligation, to manage those trust resources with the goal of their long term preservation and protection. And I would suggest to you that in that sense, the public trust Doctrine, it incorporates principles, what we now understand to be sustainable development as well as principles of inter-generational equity that the current generation shouldn't consume finite natural resources in a way that diminishes them or makes them unavailable to future generations.

0:52:15 RF: Traditionally, the public trust was understood by courts to serve three basic purposes. Commerce, navigation and fisheries, the so-called the trilogy of public trust pieces. As a result of some recent, relatively recent court decisions, the most famous of which and influential of which is 1971 decision of the California Supreme Court, coming out of a property dispute involving Tomales Bay, north of San Francisco, is that in addition to those traditional public trust purposes, the public Trust doctrine is broad enough to encompass purposes such as recreation, ecological study, open space, anaesthetic concerns, a very important modification, if you will, of the doctrine.

0:53:11 RF: Similarly, the natural resources, to which the public trust doctrine applies, have also expanded in recent years. The most traditional

application of them was to the seashore, so-called tide and submerged lands subject to the ebb and flow of the tide, so our ocean water. About a century ago, in the United States, that doctrine was extended to include the bed and banks of navigable lakes and rivers. And about 30 years ago the California Supreme Court in a public case involving Clear Lake and Lake Tahoe, and Donner Lake, expressly apply to the public trust Doctrine to inland navigable waterways, lakes, and rivers as well. Another key branch of the public trust doctrine traditionally is that fish and wildlife, at least in the wild, are also public trust resources, the oversight of which is public trust responsibility of government officials such as in California, the Department of Fish and Wildlife.

0:54:19 RF: Another key development of the public trust doctrine in recent years has been to expand even further the natural resources, to which, that are impressed with public trust doctrine. And the one that's most relevant to this course and to our discussion today are to expansion of the public trust docs to include consumptive water rights.

0:54:42 RF: And in California, at least, California was not the first state whose courts acknowledge this doctrine, but this is the most influential decision known as the National Audubon Society versus Superior Court Case better known as the "Mono Lake decision". In 1983, the decision of the California Supreme Court, without going into too much detail, I'm pretty sure the law students here are already familiar with this case and some of you, who've taken other courses, probably know about it as well, but, very briefly, starting in the very early parts of the 20th century and accelerating through the mid-20th century, the city of Los Angeles obtained water rights to the freshwater tributaries which had historically fed Mono Lake, which is a large, partially saline lake in the east of the Sierra Nevada range in California and Mono County.

0:55:41 RF: As a result of those increasing freshwater diversions to satisfy domestic water uses in Southern California, there was less freshwater flow replenishing Mono Lake and the lake level declined, became more saline. The ability of that lake to sustain brine shrimp which was a key inhabitant of Mono Lake and, in turn, serves as an important food source for a variety of bird species that inhabit the lake and use it as part of their migratory patterns. All of that was threatened and endangered. So, the National Audubon Society brought suit against the city of Los Angeles and the Department of Water Resources on a number of theories. But the one that got traction and, ultimately, was the basis for that 1983 Supreme Court decision was that water rights, the water rights obtained legally by the LA Department of Water and Power, were subject to the public trust doctrine and that the city's ability to exercise those water rights and continue to divert all or, virtually, all of those freshwater resources for domestic purposes to the detriment of the lake, that that violated the public trust doctrine.

0:57:02 RF: And its 1983 decision, the California Supreme Court for the most part, agreed with the national Audubon society, disagreed with the city of San Francisco which said or the City of Los Angeles, which had argued unsuccessfully in court that the public trust doctrine has no independent relevance to water rights in California, that they exist to the extent it's relevant at all that is both subsumed into California's longstanding statutory system of water rights. The California Supreme Court expressly rejected that notion and said that the exercise of Los Angeles water rights is subject to the public trust doctrine and that the State's water resources control board as the overseer and regulator of water rights in the State of California, has an affirmative and ongoing obligation to consider public trust values including the maintenance of the Mono Lake ecosystem as it administers and oversees water rights in California. Not just of the City of Los Angeles, but by extension, by precedent statewide. This was a very controversial decision at the time and it continues to be.

0:58:12 RF: Alright. What does that have to do with the Scott River Valley? Scott River Valley, well, you have probably a very good sense of this from our previous speakers, and again just by way of orientation, for whatever reason, my graphics showed up a little bit better than Thomas' did. Scott River Valley is at the northern most part of the State of California, Siskiyou County, one of the most sparsely populated counties in all of California, rural area. And the Scott River is a, as Thomas mentioned, an important tributary to the Klamath River Basin and Klamath River. There's a separate and independent major environmental controversy underway, that's been ongoing for a number of years about federal dams that are on the Klamath River upstream of the Scott River's confluence, and whether those dams should be taken down. And there's a long standing litigation, dispute, and settlement that is in the process of being implemented by some of those dams are in the process of being de-constructed.

0:59:27 RF: But we're focusing exclusively on Scott River as a tributary to the Klamath River which as Thomas has mentioned, among its other attributes, is an important salmon habitat, and the Scott River is the Klamath and then the tributary in the Scott River important parts of salmon, various salmon species' traditional migratory patterns. Before the expansion of groundwater pumping in the Scott River Valley, the Scott River, which it has been deemed declared navigable by the California Legislature, served a lot of traditional values, recreation and... As salmon habitat, and while the flow was good, varied dramatically by season. By and large, as Thomas mentioned, there was flow in the river, and in addition to meeting then existing water demands for surface diversions, recreational and ecosystem values were maintained including a vibrant riparian corridor.

1:00:44 RF: The problem is, that in the last two or three decades, the number of groundwater wells that have been sunk in the Scott River Valley has increased, and the pumping from those wells has increased in effort to

overcome the lack of other surface water supplies. And, as a result of that groundwater pumping, is relatively brought in to see that the impact is as is illustrated here, that certainly in certain seasons of the year, and in drought periods such as we're experiencing over the last several years, the Scott River is not only not navigable, but is largely dry for significant portions of the year, and that has the obvious deleterious impact on public recreation, on riparian habitat, and certainly on salmon habitat and migratory patterns.

1:01:47 RF: So, as a result of those activities, and then there's one other key set of facts that does not... One fact that is not developed on the PowerPoint, and that is, that as a result of legislation several decades ago, the legislature directive, that the groundwater of the Scott River, around the Scott River itself, that the groundwater be adjudicated. That is, that individual rights to specific amounts of groundwater be determined by a court. That adjudication has occurred. To the best of my knowledge... And there are other people who know far more about this than I... But the Scott River is one of the only groundwater basins north of the Tehachapi, north of Southern California, that has been adjudicated, and might be the only one. It's very rare that groundwater basins outside of Southern California are adjudicated. The Scott River Valley is the exception rather than the rule.

1:02:50 RF: A key limitation, at least from the standpoint of the parties that I represent in the litigation it's currently having is that groundwater adjudication was not comprehensive in that it did not encompass the entire, even most of the Scott River Valley, but rather only affected wells, only related to wells and claimed groundwater rights for a few hundred feet from the river.

1:03:16 RF: So the concern of the plaintiffs in this case who banded together, was to determine, built on the earlier Mono Lake decision, and argue, and hopefully establish as a principle of California Environmental and Water Law, that the public trust doctrine, just as it applies to the non-navigable freshwater tributaries of a navigable lake, I.e., Mono Lake, that the public trust doctrine should and does apply equally to groundwater resources when that groundwater has a provable and demonstrated hydrological connection to the surface waters of a navigable river, I.e., the Scott River.

1:04:05 RF: This case was filed in Sacramento County Superior Court in June of 2010. The petitioners and my clients are a Bay Area based environmental organization, the Environmental Law Foundation. Additionally, the Pacific Coast Federation of Fisherman's Association, which is a trade organization of commercial fishing organizations, and along with its research arm, the Institute for Fisheries Resources. So those are the entities which collaborated to bring the lawsuit.

1:04:34 RF: On the other side of the lawsuit, on the receiving end of the lawsuit are Siskiyou County and the State Water Resources Control Board. Last week we had Michael Lauffer, the Chief Counsel of the Water Board, here

with us, and the key factual and legal claims contained in that lawsuit filed in 2010 first, that the Scott River is a navigable waterway both navigable in fact as demonstrated by its use, and its undepleted condition, and also by the legislative declaration, that it's navigable; that there is an established hydrologic connection between the surface flows in the Scott River and the groundwater basin underlying of the Scott River Valley, underlying the Scott River Valley; that the Scott River has experienced dramatically reduced flows in recent years as a result of expanding, and essentially, unregulated groundwater pumping in the valley. And that that unregulated and greatly expanded groundwater pumping has caused a number of adverse impacts on the local environment, including harm to and destruction of migratory salmon and salmon habitat in the Scott River as well as elimination of public recreational opportunities on the Scott River, and while not indicated here, also, on damage and destruction to riparian habitat.

1:05:57 RF: Based on those factual claims, most of which are not seriously disputed by the county and the Water Board. The petitioners argue that the Water Board and the county have both the authority under the public trust doctrine and the affirmative obligation to protect the public trust resources of the Scott River Valley, that both agencies have disclaimed the authority or obligation to do so, and I should state that before the lawsuit was filed, the Environmental Law foundation made several attempts, administratively to petition the Water Board to acknowledge and take action to address the public trust resource damage caused and in responses to those who administrated this petition advanced by the Environmental Law foundation, the Water Board at the time said it lacked jurisdiction. It felt it lacked jurisdiction and authority under then existing California law to do so. For effect, I'll come back in a moment.

1:07:01 RF: That in light of the county and the state board's unwillingness and refusal to protect public trust resources in the river, that the court, Sacramento County Superior Court, should issue an order requiring that Scott Valley groundwater be managed in a sustainable way consistent with the requirements of the public trust doctrine. And that in the meantime, the Siskiyou County should be barred from continuing its ongoing, essentially automatic or ministerial practice of granting any and all new groundwater well building permits that anybody in the county wanted to seek from the county. This is the only form of government approval that has until the 2014 legislation has been required.

1:07:54 RF: So, what is happened in the litigation over the last four years? First of all, Siskiyou County perhaps predictably didn't like the idea of fighting this legal battle in Sacramento County Superior Courts, so they sought to have the case transferred, known in legal circles as a 'change of venue', sought to change venue, have the court case transferred from Sacramento County to Siskiyou County where they thought probably correctly it would have a home field advantage in defending the lawsuit in these claims. The Sacramento

County Superior Court rejected, denied the motion to change venue. The county successfully got the court of appeal to review, before the case was otherwise final, review the trial court's decision refusing to change venue, and ultimately the California Court of Appeal agreed with the trial court that venue was proper in Sacramento County, that the case shouldn't be transferred, which was the result that my side was urging, but it managed to delay the case for two years while that procedural issue was playing out.

1:08:59 RF: Probably more important to the substance of the claim, the state Water Board switched sides in the litigation. Even though, administratively, when the environmental law foundation had asked, had requested informally, that the Water Board take jurisdiction and acknowledge its public trust responsibility, and the board declined to do so. Sometimes litigation can be an effective nudge, or in this case maybe a cattle prod, I don't know. But the water board ultimately concluded, and in legal filings said, "We agree with the petitioners that inter-connected groundwater that has a demonstrable hydrologic connection to surface water in the amount of water that does come within our jurisdiction, and that we, like the petitioners, read the Mono Lake decision as requiring that the [1:09:52] ____ public trust jurisdiction over groundwater pumping on these facts".

1:10:00 RF: Most importantly, last July the Sacramento County Superior Court issued a decision agreeing with the petitioners. And since it switched sides, agreeing with the State Water Board, that the public trust doctrine does in fact apply to hydrologically connected groundwater. That the public trust doctrine therefore applies to Scott River groundwater, and that the public trust protects fishing, boating, fish habitat, and ecosystem study. And that since the State board had already acknowledged in the litigation that it had public trust responsibilities and was prepared to carry them out, the judge focused on the county and said that, "Yes, the County does have affirmative obligations to consider the public trust doctrine."

1:10:47 RF: The County immediately sought a review all the way to the California Supreme Court. We actually, the petitioners, agreed that this was a sufficiently important issue in the matter of law and public policy that the Supreme Court should take it up. So, in an unusual alliance, a temporary alliance, we agreed and supported the Supreme Court taking review. But the Supreme Court didn't have to do that. And two weeks ago, Supreme Court denied review, at least at this point. So the case remains back in the trial court, and the key interesting point now is that the County has just filed a notice with the Court and with the other parties, but they are now going to claim in new filings, that since the one thing that has changed is, what we've been talking about most of the semester, that the legislator last year's passed, the governor signed a law for the 2014 groundwater legislation, and it is their...

1:11:43 RF: It is the County's view rather, that legislation occupies the filed

and displaces any rule that the public trust doctrine might otherwise have, and that therefore, California water rights system is now amended by virtue of the new groundwater legislation that we've been studying pre-empts the field in effect and leaves no role for the public trust doctrine. I for one, and I'm editorializing here, think that that's a weak argument inasmuch as there are several references in the legislation to the fact that the groundwater statute does not, and is not intended to amend or change California's substantive water rights law, but we'll see. So, we've got about seven, eight minutes for questions which I'm happy to take, but also for Maurice and Thomas. So fire away. Yes, sir.

1:12:41 S?: Yeah, I was wondering about the adjudication, and that was developed obviously to help with the problems of that groundwater connection. So how does that play out? Can they revisit the adjudication and revamp it? Or?

1:13:01 RF: I guess I would take issue with one part of your question. The whole purpose of a groundwater adjudication is to establish through a court decree, respective rights to groundwater among competing interests. So it was designed to apportion among the various claimants to groundwater, who gets what.

1:13:22 S?: But due to the problem though, right?

1:13:23 RF: The adjudication, which was done a number of years ago, did not focus on the environment public trust resources. So that was not in play, and was not decided. The other... So, as I understand it, but that caveat... The groundwater adjudication is designed and has apportioned the groundwater. But as I said, there's a geographic limitation to it. It's just a few hundred feet from the waterway, whereas as Thomas's maps point out, there are groundwater wells all over the Scott Valley, Scott River Valley. And many of those are not addressed in any way shape or form in that adjudication. I hope that answered your question.

1:14:07 S?: Yeah, thank you.

1:14:10 S?: Tom?

1:14:11 S?: One thing about this that seems problematic is the remedy you sought is tied in with what you called "well-drilling permits". But my understanding of those permits issued by the county is they're about the integrity of well construction. They're not about the extraction of water. So wouldn't they be changed to something entirely different? The remedy was to say they've got to do an examination of extraction, and the impact of the extraction on the surface water before they issued the permit.

1:14:44 RF: Yeah. In terms of a long term permanent remedy, you're

absolutely right. When we were talking about halting the issuance of the groundwater permits as so-called interim relief, or interlocutory relief, that while the court decides this matter and formulates and declares exactly what the county and the State Board's long term obligations are, to integrate public trust concerns and management with the State's, at least new groundwater regulatory role. That at least stop making the problem worse by granting new groundwater permits without even gi
g a passing glance to the public trust doctrine or the principles that underline it.

1:15:30 S?: Yes, I have a question about the groundwater-dependent ecosystems. Would redwood forest be considered in that category since most redwoods tend to grow close to water courses?

1:15:49 S?: I am... That's beyond my expertise, whether or not they actually depend on phreatophytic access to the groundwater. I don't actually think so. I mean redwoods do grow pretty far up to the hillsides, but that's just my intuitive interpretation. I don't have much expertise in it.

1:16:11 S?: Yes.

1:16:12 S?: I may have this slightly wrong, but it seems like the California Constitution says that the State shall consider the public trust. So, if we're saying your prevail on that issue doesn't necessarily mean they have to protect it.

1:16:30 RF: That's a very good point. Again, I would take polite issue with you said that the California Constitution talks about the public trust doctrine being considered. I would argue, and this is a point of some controversy, that some aspects of the public trust doctrine are found in our State Constitution, but unlike some states, including Hawaii, that explicitly do talk about the public trust doctrine and its connection to water resources, California's Constitution does not. But your larger point is absolutely correct, that the whole holding of the Mono Lake decision is that the public trust doctrine is this independent principle that water managers, including the State Water Resource Control Board, must consider in administering the California Water Rights System, including the issuance of new permits or the modification of existing water permits.

1:17:25 RF: It doesn't... The Mono Lake decision does not indicate, or much less guarantee, that the public trust doctrine always wins. It's just that it's a separate legal doctrine that water managers have an affirmative obligation to acknowledge and consider in making their case-by-case, basin-by-basin water decisions.

1:17:47 S?: So ultimately, there has to be some members, as far what you'd like the flow to be during the summer for habitats and so on and so forth. How

do you get at those numbers for this legal case? Do you ask experts later on or do you just compare it to historical baselines? Because there's a problem with your baseline. It may have just shifted you to climate change. Thomas mentioned a paper where they attribute approximately 30%, somewhere around there, to climate change for the difference in the stream flow. So how do you use historical baselines that may have shifted in our recent years due to [1:18:24] ____ sources?

1:18:25 RF: That's a very good question, and I'm only gonna even attempt to answer part of the question, and that is, how is the on-the-ground decision made, as to how the public trust doctrine applies to and influences a particular water-related decision? In that connect, I think the short answer is, "Well, courts and the State Water Board have concurrent legal jurisdiction to deal with those issues. That's the kind of very detailed, very technical issue that most courts are gonna be all too happy to hand off to the Water Board. And in the Mono Lake decision, it took about what? About 10 years after the Supreme Court's decision in 1983, it took about 10 years of administrative hearings and deliberations for the Water Board in that case to determine to what degree the City of Los Angeles's legal diversions from the freshwater tributaries to Mono Lake would be reduced.

1:19:24 RF: And that was a very, very delicate and very complex calibration process to determine. "Well, we want the lake to recover and rise to a certain level. We certainly don't want to ignore or not provide for, to some degree the domestic water needs of the City of Los Angeles that appeared to [1:19:43] ____ and met with a larger amount of Mono Lake basin water." So that's how the process is made. In terms of the baseline, now, you're getting to the engineering and the scientific principles that are beyond my expertise, and I don't know if Thomas and/or Maurice wanted to speak for that.

1:20:02 MH: Yep. Just to comment on that example. That's a real challenge for environmental water needs all the time. In some of the early years Thomas's graph showed that, the fact, there were very low flow years previously, and so having a minimum flow breaks down on the minimum flows under a natural or an undisturbed condition. It didn't meet the needs of the habitat, and we see that is similar...