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Good afternoon. As Jay said in his kind introduction, we will now shift our focus “uphill” from the shallow parts of the bay to the intertidal margins, especially the tidal marshlands.

It may be fair to start with a basic question: why should wetlands matter in a discussion of water and sediment pollution for the bay? Four reasons quickly come to my mind. First, the tidal wetlands are part of the bay, and we should include the wetlands in our thinking about the bay. Second, the tidal wetlands are natural pollutant filter, capable of filtering large amounts of bay water. This is a well established function of tidal marshlands. Third, most of the threatened or endangered species of plants and animals that live in the Bay Area depend upon the tidal marshlands. Most of these species live in the marshlands and nowhere else. Finally, as I will explain in more detail at the end of this brief talk, the tidal marshlands not only belong to the bay, but they also belong to local watersheds. As the common margin for bays and watersheds, the tidal marshlands provide special opportunities to monitor the combined and separate effects of bay pollution and watershed pollution. For the next few minutes I will focus on the function of tidal wetlands as pollutant filters.

Tidal wetlands are commonly regarded as transitional between marine or estuarine and terrestrial environments. Here we see, in bright green, the regional distribution of tidal marshlands at the time of European contact, about 250 years ago. There were about 200,000 acres of tidal marshland during this historical time.

Now let’s look at the modern view. As we can see, there has been a large decrease in the amount of tidal marshland. The amount of pollutant filter at the intertidal margin of the bay has creased by more than 80%, while there has been a 12,000% increase in the number of people living around the bay, and perhaps a 100,000% increase in the per capita consumption of natural resources. So, we might ask, what is the condition of the small amount of filter left?

Let’s take a closer look at the filter. Here we see a map of Bird Island in the South Bay produced by Kent Dedrick of the State lands Commission during the mid- 1980’s. Notice the profuse system of channels large and small. The banks of the channels can be regarded as part of the edge of the marsh, as the usual boundary between the tides and the land. This is the edge or margin of the filter, so to speak. Using a ruler about one yard long, we have determined that, historically, there was about 10,000 miles of tidal channel bank, or filter margin, around the bay. As I said, only a small portion of that amount of filter edge exists now.

It is important to recognize that this filter, a typical example of which is shown in this map, is exposed to the tides about twice daily, with different portions of the filter being exposed by tides of different height. It should also be recognized that the filter is always in a state of structural change, through vertical and horizontal accretion, the loss and gain of small channels, the coming and going of the ponds on the marsh surface, and so forth. As sea level rises, the marsh builds upward, and so the filter repairs and replaces itself through time. These are some of the ways that the filter naturally changes. Now let's look at how the filter works.

Here we see some examples of pollution filtering by the Petaluma Marsh, about seven miles upstream from the tidal entrance to the Petaluma River. These are some of the same data summarized earlier by Rainer for the Petaluma Marsh as s a whole. There are many more data available in the annual RMP report, and I will not try to present all of that data now. Rather, I will provide some evidence of the detailed workings of the pollutant filter.

Here we can see that for Mercury and Nickel, concentrations were higher along the channel banks, or the edge of the filter, than on the marsh surface. There are exceptions, but this is the general pattern we see for metals, with higher concentrations at the margins of the filter.

But here we see that concentrations of some pesticide residuals, such as Chlordanes, were higher on the marsh surface than along the channel banks. For other pollutants, such as DDT's, the channels and marsh surface had similar concentrations. So, we can see that different parts of the filter work for different kinds of pollutants.

The spatial variation in filtration within tidal marshland is further illustrated by the way the tidal marsh works as a filter for suspended sediment. Here we see a set of three xrays of shallow cores along a transect from a channel bank to a place away from any channels. The darker areas in the xrays represent the very fine grain inorganic sediments delivered by the tides. We can see that the amount of inorganic sediment decreases with distance away from the channel bank, or margin of the filter. By looking up and down within any one of these cores, we can also see that the amount of inorganic sedimentation varies through time, at each position along the transect. These temporal variations have to do with regional variations in sea level rise, and subregional variations in sediment supplies.

We can use the sediment filtration function of tidal wetlands to illustrate their role in the overall sediment budget for the bay. We have yet to calculate the historical or modern suspended sediment load annually retained by tidal marshlands (how much is filtered by the marshlands), but we have begun to understand how tidal marshlands work as part of the natural margin between the bay and a local watersheds. We know, for example, that the loss of tidal prism due to tidal marsh reclamation has resulted in the severe shoaling of the tidal reaches of rivers and creeks around the bay, and the in-filling of submerged channels leading from rivers and creeks to the deeper parts of the bay. Simply stated, the tidal channels that serviced the marshlands have become smaller as the marshlands have been diked, as the sediment that used to go to the marshlands has been left in the bays and tidal channels. For example, here we see, in brown, how sediments accumulated in the major channels leading from the rivers and creeks around San Pablo Bay to the main channel of the Sacramento River. This image is provided to us by Richard Smith and Bruce Jaffe of the US Geological Survey in Menlo Park. What I would like us to be reminded by this image is that the loss of tidal marshland not only means a loss of filtering action by the intertidal margins of the bay, but it also means that sediments accumulate and are stored in lower places, like shipping channels. So, a decrease in tidal wetlands can mean an increase in dredging.

Now lets look into the local watersheds, on the other side of the intertidal margins of the bay. In this drawing of typical historical conditions around the bay, as evident along the transect from stations 1 through 5, we can see how the tributaries of a local watershed came together and flowed into tidal sloughs and then into the bay. For our local watersheds, it is expected that the historical sediment sources were located in the headward, steeper reaches of the creeks. The sediment was mostly transported through the middle reaches, and stored in the lower, least steep reaches, with some sediment reaching the bay.

Now let's turn our attention to the same place under modern conditions, with the creek damned in its headwater reaches, buried underneath the urbanized lowlands, and the tidal marsh carved up into various modern land uses. These are pictures of tidal wetlands as margins between the bay and local watersheds.

Collaborative efforts among researchers and local agencies that began last decade in Wildcat Creek, two years ago in Huichica Creek, last year in Novato Creek, and that are just beginning in Permanente Creek show that a combination of climate change and land use has caused downcutting and headward extension of creeks in their steeper reaches, downcutting of the creeks in their middle reaches, and accumulations of large amounts of sediment in the lower reaches, relative to historical conditions. One overall change has been large increases in local sediment supplies to the margins of the bay. The increase in local sediment supplies, in combination with the reclamation of tidal marshlands (the destruction of the filter) has increased the flooding hazards and has contributed substantially to the continuing need to dredge the tidal reaches of the rivers and creeks.

So, why does all of this information about wetlands relate to bay pollution? At least three reasons present themselves.

First, the tidal marshlands are part of the bay, and they are at least as polluted as the other parts, for most kinds of chemical pollutants. Whether this pollution is significant or not is a matter of perspective, and will need to be assessed. But it might be important to remember that most of the endangered or threatened species of plants and animals in the region inhabit the tidal wetlands. It might also be noted that the observed concentrations of mercury in the marshlands exceed the expected threshold for egg mortality for the California Clapper Rail, an endangered bird species that lives only in the bay marshlands.

Secondly, sediment itself is a pollutant, if dredging is not desirable. And the loss of tidal marshlands has greatly increased the need for dredging.

Thirdly, wetlands are transitional parts of both the bay *and* the local watersheds. The tidal marshes belong to the watersheds and to the bay. Transects that are arrayed along the marshlands parallel to the rivers and creeks can therefore be used to measure the combined and separate effects of local and regional pollution. Here we see a regional map that shows a small number of the possible bay-wetlands-watersheds transects that could be established to map the spatial extend of bay and watershed pollution. We would expect that the bay influences would decrease in the upstream direction along these transects, and that watershed influences would decrease in the downstream direction, though the intertidal margin and shallow margins of the bay.

In support of this idea to measure the relative influences of bay and watersheds, Rainer will now present some of the results of the RMP Watersheds Pilot project.