Flood Protection Provided By Our Lagoon Drainage System

LETTER TRANSMITTING DRAFT REPORT

From: Bob Cushman <boborsandy@aol.com>
Subject: Re: Lagoon pumping capacity
Date: October 28, 2016 at 9:51:41 AM PDT
To: "jmoneda@fostercity.org" <jmoneda@fostercity.org>

Hi Jeff: I have attached a discussion draft titled: “Flood Protection Provided by Our Lagoon System”. As you know, I support raising the levee. I have written this piece so we can better understand the level of protection provided by our lagoon system and assure that it becomes part of the discussion about our need to raise the height of the levee, now and in the future

Would you share this with your staff people, have them evaluate it, and share the result with me. Please also share it with our consultants, Terry Huffman and Robin Lee. They expressed an interest in receiving a copy of this piece, too. I was impressed with them. I'm glad they are on board.

As i mentioned to you last night, I need to leave town again to tend to my brother, who is in Portland. I will be back Tuesday night. I have a series of questions I would like to ask about the levee so please set me up for a time to meet with you. I am retired so can meet most any time. Please avoid Tuesday and Thursday mornings. That is when I play senior “swing and miss” softball.

Thank you for your continued good service to our City.

Bob Cushman
602 Greenwich Lane
Foster City, CA 94404
boborsandy@aol.com
650-341-4309

RESPONSE FROM DIRECTOR OF PUBLIC WORKS

From: Jeff Moneda <jmoneda@fostercity.org>
Subject: RE: Lagoon pumping capacity
Date: November 7, 2016 at 4:19:37 PM PST
To: Bob Cushman <boborsandy@aol.com>

Hi Bob,
Thank you for your report. We have reviewed your request to consider only meeting FEMA requirements for the Levee Improvement project. You indicate that the lagoon is capable of serving as a detention basin if we lower the lagoon level by a few feet. Removal of water would most likely jeopardize property owner's bulkheads. The water in the lagoon currently provide lateral pressure to bulkheads. In addition, please note that this would deem our lagoon not usable for recreational use. We already receive complaints from users of the lagoon when we lower the lagoon water level.

In addition, our lagoon pumps are at an elevation several feet below the top of levee. Due to the difference in elevation and resultant head pressure, a breach of the levee would deem our pumps not usable, and even the largest of pumps would not be able to keep up and large head pressures could cause a back-siphon of water from the Bay into the lagoon.

The City's hybrid design (sheet pile and earth backfill), earthen levee, block wall levee, and horizontal levee alternatives are being considered as design alternatives in the Environmental Impact Report. Please note that the public will be given an opportunity to comment on the EIR and the various levee alternatives, which is anticipated to be adopted in January 2017. We anticipate the City Council to provide direction on levee height alternatives at its meeting in February 2017.

We appreciate your input regarding the project. If you would still like to meet on Monday, November 14th, please let me know. Also, if you have any additional questions, please contact me.

Thank You,

Jeff

From: Bob Cushman <boborsandy@aol.com>
Subject: Re: Lagoon pumping capacity
Date: November 16, 2016 at 10:21:07 AM PST
To: "jmoneda@fostercity.org" <jmoneda@fostercity.org>

Hi Jeff: Thanks for responding. And thanks for letting me know that we have a third pump that we are not using. This changes the calculations but not the basic notion.

Your response, below, leads me to some suggestions. I would like your advice about how these can be implemented.

Let's assume we have raised the levee but still encounter a storm scenario in which water from the Bay begins to flow over the top of our levee. What adaptability options do we have? We can add sand bags to the top of the levee and do all the usual stuff. But, in addition, we have a lagoon drainage system we should plan to employ. Your response to me suggests two clear actions we should take:

1. We should not allow ourselves to get into a situation where the pumps cannot be employed because, as you said in your response, they are currently "at an elevation several feet below the top of the levee." How can we make sure that we raise the pumps as we raise the levee. There may be other options; e.g., submersible pumps to help lower the lagoon, pumps mounted on floats; and/or we might also increase our pumping capacity.

2. We need to define the flood circumstances that will justify emptying the lagoon so our pumps can attempt to stay ahead of the water entering our lagoon system. Also, we need to establish the protocol for doing so. I realize this would put some of our bulkheads at risk but I can foresee a situation in which risking possible damage to the bulkheads would be preferred to the certainty of much greater property damage. This is not something we want to leave to when we might have a dire emergency on our hands. How do we get this put into place?

3. The third action, which is pretty basic, is to incorporate this adaptability feature into our flood prevention and flood management emergency planning, and is a part of our strategy, as we consider raising the levee.

Bob Cushman
602 Greenwich Lane
Foster City, CA 94404
boborsandy@aol.com
650-341-4309

10-28-16 discussion draft Cushman

Flood Protection Provided by our Lagoon System

Our lagoon system provides the City with a unique advantage if water were ever to top our Foster City levee.

"The Foster City Lagoon as a drainage detention basin is designed to withstand successfully a storm of 100 year return frequency, or a storm of such severity that it is likely to occur only once each century. The lagoon therefore provides maximum drainage security for Foster City. Stormwater collected throughout the City flows to the Foster City Lagoon. All storm water enters the storm drain system through curb inlets and catch basins, and drains into the lagoon from which it is pumped into the bay.

How well does the Foster City Lagoon system work as drainage catch basin? During the El Niño rainstorms of 1997/98, which were very close to a 100-year frequency severity, the City of Foster City experienced no flooding while surrounding cities in San Mateo County experienced major drainage problems. Thanks to the effectiveness of its lagoon system, Foster City has never experienced major flooding." [1]

The following is a layman's attempt – a beginning attempt[2] -- to quantify the extent of this protection.

The purpose of the piece is to better understand the level of protection provided by our lagoon system and assure that it becomes part of the discussion about our need to raise the height of the levee, now and in the future

The assessment is based on the following:

1. The total capacity of our lagoon system is 64,643,040 cubic feet of water.[3]

---

[1] Source: http://www.fostercity.org/publicworks/lagoonandlevee/Lagoon-Information.cfm

[2] The Department of Public Works has retained consultant expertise to evaluate and add to this analysis.

[3] One acre =43,560 square feet. Our lagoon system covers 212 acres and averages 6 feet in depth. It is kept one to two feet below 100 elevation, the point at which water would begin to flow over the lagoon bulkheads. This means the total capacity of the lagoon can be conservatively

2. We can pump water from our lagoons to the Bay at a maximum rate of 560 cubic feet per second. At that rate it would take 32.065 hours to pump all the water out of the lagoon.

3. If our lagoon were full, and water came over the top of the levee at the same rate it was being pumped out, the level of water in the lagoon would remain unchanged. It would be at steady state.

4. Our 8-mile levee system is 42,240 linear feet long [4]

5. The lagoons would remain at steady state if no more than 1,530.75 cubic feet of water came over the top of each linear foot of the levee in a 32.065 hour period. This rate is just under one tenth of a gallon per second along the entire length of the levee.[5]

6. If the lagoon were empty or near empty at the time the water topped the levee, the amount of water that could be allowed to flow over the top of the levee could be doubled. (To 0.19489596 gallons per second) However, there is risk of bulkhead failure if the level of the lagoon were to be emptied. This is because the water exerts pressure on the bulkheads.

7. Bigger capacity pumps could provide increased protection from any flooding. For example, pumps with five times the current pumping capacity could accommodate about one full gallon of water topping the entire length of the levee every second over a 32 hour period.

---

estimated at 212 acres x 7 feet in depth. 212 acres x 43,560 sq ft x 7 foot depth = 64,643,040 cubic feet of water.

[4] We have 8 miles of levee. A mile = 5,280 feet, thus our levee system consists of 42,240 linear feet.

[5] The pumps can pump out 560 cubic feet of water per second, so it would take 32.065 hours to empty the lagoon or, conversely, it would take 32.065 hours [115,434 seconds] to fill the lagoon if a total of 560 cubic feet of water/second came in over the top of the levee. Total capacity of the lagoon system= 64,643,040 cubic feet of water divided by 42,240 feet of levee means a total of no more than 1,530.75 cubic feet of water could flow over the top of the levee in a 32 hour period to equal the amount of water being pumped out. This would produce a steady state level of the water in the lagoon system. 1,503.75 cubic feet/115,434 seconds = 0.0132575 cubic feet per second over the entire length of the levee. This is just under one tenth of a gallon per second of water coming in along the entire length of the levee. (.0130269 cubic feet =0.09744798 gallons of water.).

8. Rainfall during this 32-hour period would invalidate all these calculations. On the other hand, these are conservative estimates because the soil and vegetation will absorb some floodwater before it runs into the lagoon.

9. A talented engineer provided a more complex formula for estimating the flow over the levee that would exactly match the ability of the pumps to discharge the water, thereby creating a steady-state level of water in the lagoon.

This approach tells us that a steady 0.22 inch of water higher than the top of the levee would allow 561.0 cubic feet of water/second to flow over the top of the entire length of the levee. This is about the maximum amount of floodwater the existing pumps could handle.

The first column in the following table shows the capacity of the pumps needed to create a steady state in the level of water in the lagoon system if the water is anywhere from 0.20 inches to 1 inch above the top of the levee.

For example, if the water were a constant 0 .20 inches above the top of the levee, the steady state of water in the lagoon system could be achieved by pumps with 486.2 cubic ft/second capacity. If the water were a constant 1.00 inch above the top of the levee the pump capacity would need to rise to 5,436.3 cubic feet/second, or nearly ten times the capacity of our existing pumps.

Calculating Pump Capacity (Q flow) to Absorb Water Higher From .20 inches to 1.0 inches Than the Levee (Hin)

Q flow cu ft/sec	H(in)	H (ft)	B levee in ft	G gravity	Levee (mi)
486.2	0.20	0.017	42240	32.2	8
523.2	0.21	0.018	42240	32.2	8
561.0	0.22	0.018	42240	32.2	8
599.6	0.23	0.019	42240	32.2	8
679.5	0.25	0.021	42240	32.2	8
5436.3	1.00	0.083	42240	32.2	8

The formula is:

Q = (2/3)*B*sqrt(2*G)*H*sqrt(H) flow rate in qu ft per sec, H in ft, B in ft.

Discussion:

The very basic calculations provided here show that our existing pumps can handle a constant flow of about 1/10th of a gallon per second over the top of the entire length of our 8 mile levee over a 32 hour period. At this rate, the lagoons would be in steady state; that is, the level of the water would remain unchanged. This is because the rate at which the water is being pumped out would equal the amount of water flowing over the top of the levee.

A second calculation, using a formula provided by an engineer, shows that if the Bay water stayed at a constant 0.22 inches above the top and all along the entire 8 mile levee, our pumps would create this same steady-state in the level of water in our lagoons.

Both of these calculations assume the lagoon system is full when the flooding starts and produces a steady state, where the level of the water in our lagoon systems neither rises nor falls.

The two estimates, one of one tenth of a gallon/sec; the other a flow of 0.22 inches/second suggest that flooding will occur even if a very small amount of water tops the levee. This is because the models have the water constantly flowing over the entire 8 miles of levee.

Five more considerations that increase our protection:

1. If the lagoon levels were lowered, prior to the flooding, then the ability of the lagoon system to absorb floodwater would increase. The maximum case would be if the lagoon system were empty when water began to top over the levee. In that case twice as much water could drain into the lagoon over a 32 hour period before it would reach capacity and flood. This would double the flow from 1/10th of a gallon/sec to 2/10ths of a gallon /sec., or in the second example, from 0.22 inches/second to 0.44 inches per second.

2. It is unlikely that the flow of water topping the levee will be constant. This will give the pumps opportunities to “catch up” by continuing to pump out water when it is not flowing in over the top of the levee. For example, it is reasonable to expect that, at least initially, small waves will wash up and over the top of the levee. In that case, the flow of water over the top of the levee is unlikely to be constant. For example. a constant flow of 1/10th of a gallon of water/second would be roughly equal to waves containing one full gallon of water topping the levee, arriving 10 seconds apart.

3. It is unlikely that any constant flow of water over the top of the levee will last more than 32 hours. High tide will pose the most risk but low tide will considerably lower the water on the Bay side of the levee. This would give our pumps time to "catch up" by continuing to pump water back into the Bay while water is not coming in over the top of the levee.

4. The City could add more pumping capacity. Once FEMA certification is attained, this would be cheaper than adding more height to the levee. This is an example of how adaptability can be built into the project.

5. These calculations do not include any provision that might account for rainfall during the time water may be topping over the levee.

Conclusion: Our lagoons provide flood protection not available to other communities. For flooding to occur in Foster City, more water would have to come over the top of the levee, and at a faster rate, than our existing pumps could discharge it back into the Bay.

The rough calculations provided here show that the lagoon system is capable of accepting heavy rainfall without filling up, even very heavy rainfall. It is also capable of accepting small amounts of water topping over the levee. But it is not sufficient to accommodate large volumes of water that might top the levee. Thus, we cannot depend solely upon the lagoon system for protection during severe storm surge. it is important for us to raise the levee

The analysis suggests:

1. We should increase the height of our levees only to a height that matches our neighbors. Anything less puts them at risk; anything more will not protect us from water coming in from other cities.

2. At any given height of the levees agreed to with our neighboring cities, we will have more flood protection than they will because of our lagoon drainage system.

3. The analysis supports an argument to improve our levee to meet only the MINIMUM needed to achieve FEMA certification (accreditation). Our lagoon system provides additional protection.

4. Once FEMA certification has been achieved, buying bigger pumps will be cheaper than building an even higher levee. It adds adaptability.