M E M O R A N D U M

TO: Mayor and Council

FROM: Joseph G. Pantalion, P.E., Director
Watershed Protection Department

DATE: March 2, 2016

SUBJECT: **Onion Creek Floodplain and Flood Mitigation Study**
Flood Mitigation Feasibility Analysis

In response to the 2013 Halloween flood on Onion Creek, the Watershed Protection Department (WPD) is studying feasible flood mitigation options as part of an overall Onion Creek Floodplain Study. The study is separated into two phases. WPD provided our consultant with the notice to proceed with Phase 1 of the study in October 2014 and with Phase 2 in April 2015.

Phase 1 included field surveys of home elevations and high water marks from the 2013 Halloween flood. This information is being used to support the active buyout project in the Lower Onion Creek area in addition to providing data to calibrate the engineering models. Phase 2 includes the floodplain modeling and mapping of Onion Creek, Bear Creek, Little Bear Creek, Rinard Creek, and several small tributaries to create new regulatory floodplain maps for the City of Austin in addition to floodplain maps for FEMA flood insurance purposes. Phase 2 also includes the evaluation and recommendation of flood mitigation alternatives for the portion of Onion Creek between IH-35 and East Slaughter Lane.

As requested by City Council following the October 30, 2015 flood event, our engineering contractor has completed a feasibility-level analysis of potential flood mitigation options for the portion of the Onion Creek watershed between IH-35 and East Slaughter Lane (the focus area). Mitigation options were evaluated with the goal of eliminating potential inundation of buildings in the focus area during the 1% annual chance event (1% ACE) or 100-year flood event.

The flood mitigation alternatives evaluated fall into four primary categories:

1) regional detention,
2) floodwalls,
3) channel modifications and clearing, and
4) property buyouts.

These alternatives were evaluated at a conceptual level with a focus on the elimination of flood risk rather than the potential permitting constraints. Feasibility-level construction and life cycle costs were developed for each evaluated alternative. The attached report documents these evaluations, presents the estimated costs associated with each, and discusses some of the potential construction and permitting challenges.

In order to fully mitigate the flooding issues in the focus area, the analysis concludes that extensive projects would be required. Two of the alternatives, comprehensive buyouts and construction of floodwalls with limited buyouts, would completely eliminate the risk of flooding in the focus area. The other evaluated alternatives independently would not completely eliminate the risk of flooding and would need to be combined with other options in order to achieve the mitigation goal. Each of the alternatives would have significant impacts on the Onion Creek neighborhood and Onion Creek Golf Club and each would have environmental and permitting challenges that will need to be further evaluated. A brief discussion is included below for the flood mitigation alternatives that are currently the most effective at achieving the mitigation goal.

Comprehensive Buyouts – This includes real estate services, appraisals, acquisition costs, relocation/moving expenses, asbestos testing/abatement, demolition, and property management during the buyout process of homes inundated by the 1% ACE floodplain. The estimate of probable cost of property acquisition for 147 properties is approximately $91 million.

Floodwalls – While floodwalls would provide flood mitigation in the focus area, the construction of these floodwalls would require significant number of property acquisitions, impacts to the golf course, and a substantial internal drainage systems to drain local runoff. Two separate floodwalls would be required along Pinehurst Drive and Wild Dunes Drive. The estimate of probable cost for the floodwalls is approximately $81 million.

WPD does not currently have sufficient funding to implement buyouts or initiate project design, permitting, and construction for a flood mitigation solution in the focus area. Once funding is identified, the comprehensive buyout option could take at least two years to complete. The timeframe to design, permit, and construct the floodwall option would be approximately four years.

We will further refine and evaluate the most promising combinations of alternatives through the preliminary engineering portion of the study. The accelerated nature of the feasibility-level analysis has limited our ability to elicit input and feedback from stakeholders in the Onion Creek neighborhood. We plan to involve representatives from the neighborhood much more directly during the next phase as we develop and refine the alternatives into an implementable project. As mentioned above, we will need to make significant decisions in order to achieve an acceptable balance among flood protection goals, impacts to the neighborhood, and permitting and environmental considerations. Given the potential impacts to the neighborhood, it will be important to have stakeholder input, including meetings with the public. We will work with our consultants and stakeholders to complete the preliminary engineering process by the end of September 2016 as indicated in the current study schedule.

We look forward to the opportunity to present the results of this feasibility-level analysis at the joint Open Space, Environment, and Sustainability Committee and Public Utilities Committee meeting on March 23, 2016. We also look forward to working with you and with other stakeholders in the project to develop effective flood mitigation solutions for the focus area. If you have any questions about the feasibility-level analysis or the floodplain study in general, please contact Kevin Shunk, P.E., at 512-974-9176 or Kevin.Shunk@austintexas.gov.

Attachment

CC: Marc A. Ott, City Manager
Sue Edwards, Assistant City Manager

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4030 West Braker Lane, Ste. 450
Austin, Texas 78759
(512) 777-4600
Fax (512) 252-8141

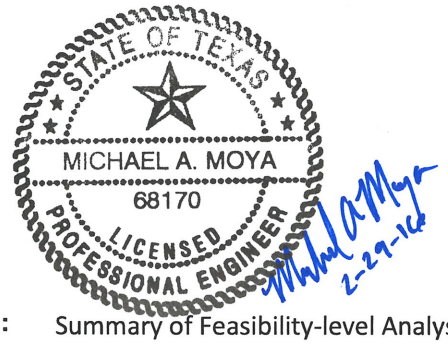
MEMORANDUM

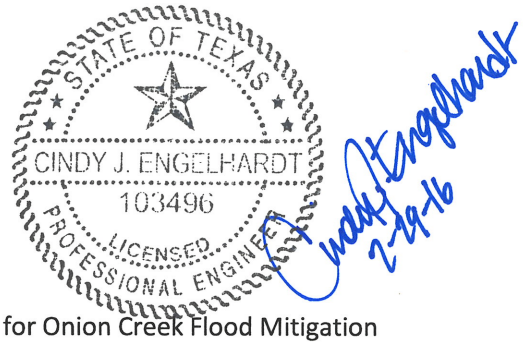
TO: Kevin Shunk, PE, CFM
City of Austin

DATE: February 29, 2016

FROM: Michael A. Moya, PE, CFM and Cindy Engelhardt, PE, CFM

AVO: 27490B





SUBJECT: Summary of Feasibility-level Analysis for Onion Creek Flood Mitigation

INTRODUCTION

In response to the October 2015 flood along Onion Creek, the Austin City Council requested an accelerated conceptual evaluation of potential flood mitigation alternatives. The flood mitigation concepts discussed in this memorandum are preliminary. These high-level feasibility concepts will be refined through subsequent preliminary engineering analysis and coordination with project Stakeholders.

The Onion Creek drainage basin encompasses approximately 344 square miles. Onion Creek generally flows easterly, from the headwaters in Blanco County, through Hays County, to the confluence with the Colorado River in Travis County. To validate the updated hydrologic and hydraulic analysis, the study team has simulated three historical events (October 2013, May 2015, and October 2015) using City provided gage-adjusted radar rainfall. These historic simulations were conducted to evaluate and compare peak discharges, hydrograph trends, and observed high water marks. The model was then used to update the frequency analysis along Onion Creek. The updated frequency analysis redefines computed peak discharges and water surface elevations along Onion Creek. The preliminary results from the updated existing development condition 1% (100-yr) annual chance event (ACE) were used as the baseline for this flood mitigation analysis. These preliminary hydrologic and hydraulic results will be further refined as the study progresses. Additionally, during the subsequent preliminary engineering evaluation of alternatives, the fully developed condition 1% ACE flows will be used for the final alternative configurations.

MITIGATION GOALS

The flood mitigation analysis consists of the development and evaluation of alternatives, both structural and non-structural, to reduce flood levels along Onion Creek. Potential flood mitigation alternatives were evaluated based upon a high-level feasibility of each proposed alternative, its cost effectiveness, and the potential for implementation. Specifically, the analysis focused on the identification of flood mitigation alternatives along Lower Onion Creek, within City of Austin's jurisdiction, between IH-35 and East Slaughter Lane. This includes portions of the Onion Creek subdivision adjacent to Pinehurst Drive, River Plantation Drive, and Wild Dunes Drive. The overall flood mitigation objective is to eliminate the risk of interior flooding of structures during the 1% ACE and to reduce the extent of roadway flooding to meet the City's drainage criteria regulations.

In order to significantly reduce structure flooding between IH-35 and Slaughter Lane, the flood elevations from the 1% ACE need to be reduced to levels comparable to a flood event with a frequency between the 4% (25-year) and 2% (50-year) ACE. This reduction can be accomplished using hydrologic alternatives (detention/retention ponds), hydraulic alternatives (diversions, floodwalls, channel improvements, etc.), or a combination of these alternatives. Analysis of potential improvements was conducted to potentially convey floodwaters within existing or proposed channel easements and roadway right-of-ways. The goal of this conceptual analysis was to identify alternatives that would either reduce the 1% ACE peak discharges by approximately 30% or produce equivalent water surface elevation reductions ranging from 2 to 5 feet through the study area.

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Fax (512) 252-8141

Illustrations and opinion of probable construction costs for the identified alternatives are attached.

Hydrologic Sensitivity

The primary goal of hydrologic alternative analysis is to reduce the peak discharge along Onion Creek between IH-35 and Slaughter Lane. Peak flows in this area are computed based upon a combination of flows from the main portion of the upstream Onion Creek watershed, and flows from Bear Creek watershed that join Onion Creek at Twin Creeks Road. The flows are also influenced by the larger Onion Creek tributaries upstream of the City of Buda. Onion Creek tributaries with significant drainage areas upstream of Slaughter Creek were evaluated to determine if the peak discharge from the tributary coincided with the Onion Creek main stem peak discharge. Tributary peak discharges that are very close in time (coincident) to the peak of the main stem result in a significant increase to overall peak discharge along Onion Creek. Detention within the coincident peaking tributary watershed could optimize the attenuation of flood waters from the tributary and thereby reduce the total peak discharge along Onion Creek. Only one tributary (South Onion Creek in the upper basin) peaked at the same time as the Onion Creek main stem; however, detaining South Onion Creek resulted in minimal peak reductions along Onion Creek in the lower basin between IH-35 and Slaughter Lane. Based on the findings of this sensitivity analysis, hydrologic flood mitigation alternatives were concentrated on Onion Creek (main stem) detention.

Hydraulic Sensitivity

The preliminary results from the updated 1% ACE were used as the baseline for the hydraulic flood mitigation alternative evaluation. Approximately 222 structures are located within the preliminary 1% ACE floodplain footprint between IH-35 and Slaughter Lane. Of these structures, 163 are located in the Pinehurst area, 54 are located in the Wild Dunes area, and 5 are dispersed along the study area. Evaluation of available finished floor elevations indicate that approximately 120 structures (Pinehurst area) and 27 structures (Wild Dunes area) are estimated to be inundated by the computed 1% ACE. The hydraulic analysis revealed that the computed 1% ACE water surface elevation profile displays three localized increases in water surface elevations (head loss) between IH-35 and Slaughter Lane. Such water surface increases are generally caused by inflow from large tributaries or channel constrictions where the cross-sectional area (conveyance) of a channel is reduced. Since the water surface elevations upstream of the Slaughter Creek confluence exhibit a sloped gradient, the downstream localized increase in water surface elevation was not caused by Slaughter Creek. Therefore, hydraulic flood mitigation alternatives were concentrated on the modification of channel constrictions such as natural changes in channel geometry or man-made constrictions likely caused by development and roadway crossings.

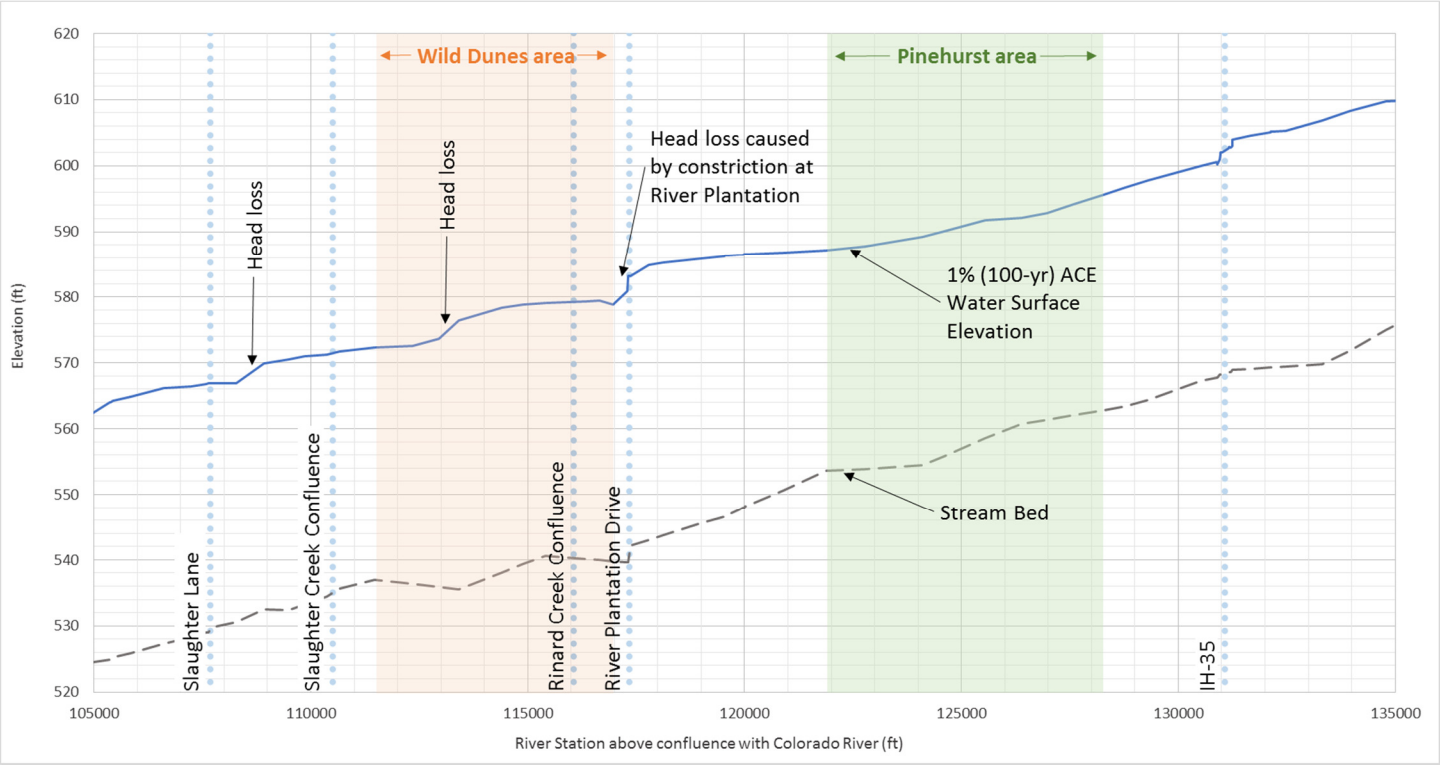

Figure: 1% (100-yr) ACE Water Surface Elevation Profile

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Fax (512) 252-8141

HYDROLOGIC MITIGATION ALTERNATIVES

Hydrologic detention is used to temporarily impound flood waters for later release in order to reduce peak discharges or to alter the timing of flood flows within a watershed. Potential hydrologic improvements were modeled and evaluated utilizing the updated hydrologic frequency analysis. This conceptual-level analysis included the identification of several potential offline and inline pond locations upstream of IH-35. Existing topography was evaluated for favorable locations where a regional detention pond could potentially be constructed. The ponds were conceptually configured to allow the more frequent events (4% ACE and below) to bypass or pass through the pond, while detaining the less frequent events with a focus on reduction of the 1% ACE flows. The following conceptual pond locations were analyzed:

- **Centex West Pond** – The Centex West Pond utilizes the active Centex quarry as an offline detention pond. Since the existing quarry is essentially a large excavated hole in the ground, it is ideal for flood diversion and reduction. Flood waters would be diverted from Onion Creek main stem into the Centex West Pond and then released back into Onion Creek at a reduced rate. The Centex West Pond has an approximate existing capacity of 5,700 acre-feet which could be utilized to produce about a 10% reduction of the computed 1% ACE peak discharge at the Pinehurst and Wild Dunes areas. This 10% reduction in peak discharge results in a reduction of approximately 0.5 – 1.0 feet in computed 1% ACE water surface elevation in the Pinehurst and Wild Dunes areas. Construction of an offline detention pond at this location would require extensive negotiations with the property owner and the quarry operator to allow for disruptions to mining operations during and after flood events and to establish agreements regarding the property and detention pond once mining operations are eventually complete.
- **Centex East Offline Pond** – The Centex East Offline Pond utilizes the previous Centex quarry along Mustang Branch as an offline detention pond. This location would require the construction of a dam along Mustang Branch to detain flood water. With a dam height greater than 6 feet, this location would be subject to TCEQ dam regulations. Similar to the Centex West Pond, flood waters would be diverted from Onion Creek main stem into the Centex East Offline Pond and then released back into Onion Creek at a reduced rate. The Centex East Offline Pond has an approximate capacity of 2,300 acre-feet. Since this pond is located along Mustang Branch and must accommodate flows from this tributary watershed, flood reduction is limited to about a 3-5% reduction of the computed 1% ACE peak discharge at the Pinehurst and Wild Dunes areas. There also are two planned roadway projects in the area (expansion of FM 1626 and construction of the Kyle Loop) that would impact the pond and reduce the available storage volume. Given the minimal benefits and multiple constraints, the viability of this pond is low.
- **Centex East Inline Pond** – The Centex East Inline Pond utilizes the previous Centex quarry along Mustang Branch as an inline detention pond. This pond configuration would require the construction of a dam across Onion Creek to detain flood water and cause it to pond in the former quarry area. With a dam height greater than 6 feet, this location would be subject to TCEQ dam regulations. Unlike the two Centex offline ponds, this inline pond would be designed to allow for the more frequent events to pass while detaining the less frequent events using an optimized dam outlet structure. The Centex East Inline Pond has an approximate capacity of 4,100 acre-feet. Since this pond is located along Onion Creek, the flood reduction is somewhat limited, resulting in about a 7% reduction of the computed 1% ACE peak discharge at the Pinehurst and Wild Dunes areas. Given the minimal benefits and multiple constraints, the viability of this pond is low.
- **IH-35 Inline Pond** – The IH-35 Inline Pond utilizes the natural topography of the Onion Creek floodplain valley just downstream of Buda, Texas near IH-35. This location would require the construction of a large dam across Onion Creek to detain water. With a dam height greater than 6 feet, this location would be subject to TCEQ dam regulations. Similar to the Centex East Inline Pond, this inline pond would be designed to allow for the more frequent events to pass while detaining the less frequent events using an optimized dam outlet structure. The IH-35 Inline Pond has an approximate capacity of 12,300 acre-feet, which is sufficient to produce about a 13% reduction of the computed 1% ACE peak discharge at the Pinehurst and Wild Dunes areas. Although this inline pond has the potential to produce reductions in peak discharge, the feasibility of constructing this large dam along Onion Creek is minimal due to environmental and economic constraints. This is similar to the conclusions of the USACE Interim Feasibility Study findings.

HYDRAULIC MITIGATION ALTERNTIVES

A broad range of conceptual hydraulic alternatives were evaluated to mitigate flooding in the Pinehurst and Wild Dunes areas. These hydraulic alternatives include the construction of floodwalls, diversion channels, and channel modifications in order to reduce the computed 1% ACE water surface elevation. Potential downstream impacts associated with these mitigation options will be evaluated during subsequent preliminary engineering analyses. Each mitigation alternative discussed in this section was independently evaluated utilizing the updated Onion Creek hydraulic frequency analysis.

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Austin, Texas 78759
(512) 777-4600
Fax (512) 252-8141

Pinehurst Area

Approximately 120 structures in the Pinehurst portion of the Onion Creek subdivision are estimated to be inundated by the updated existing condition 1% ACE. In an effort to reduce flooding within the Pinehurst area, the following hydraulic mitigation alternatives were conceptually evaluated.

- **Floodwall** – Floodwalls provide high levels of flood protection to flood prone areas but also require substantial amounts of conveyance along the stream corridor. Due to the topography and location of the upper channel bank in the Pinehurst area, the alignment of the proposed floodwall would generally parallel Pinehurst Drive for approximately 6,200 feet. The average height of the wall is approximately 7 feet with a maximum height of 16 feet. Construction of a floodwall in this location would also require the acquisition of about 55 structures along the southern side of Pinehurst Drive. FEMA criteria require the floodwall to have a minimum freeboard (height above the 1% ACE water level) of at least 3 feet for the entire wall and 3.5 to 4.0 feet of freeboard at the upstream and downstream tie-in locations. In addition, an internal drainage system would be required to drain approximately 110 acres of local runoff behind the wall. Without the purchase of the 55 properties, construction of a floodwall would be considerably less practical. The wall would need to be located as close to the existing structures as possible in order to minimize the height. Even if located immediately adjacent to the existing structures, the average height (and cost) of the wall would significantly increase.
- **Channel Diversion** – Diversions of flood water can be constructed to more efficiently convey flood waters through a channel oxbow. Caution must be used to identify and mitigate potential downstream impacts where the diversion channel re-enters the creek. A 150-foot wide diversion channel was evaluated through the golf course to the north of the impacted Pinehurst properties in order to convey flood waters around the homes. Construction of the channel diversion independent of other mitigation alternatives resulted in water surface elevation reductions near the upstream end of the diversion but had limited benefit at the downstream end where it re-enters Onion Creek due to the tail water conditions in Onion Creek. In order for this alternative to be beneficial for the entire Pinehurst area, the channel diversion would need to be coupled with significant downstream channel modifications that would reduce the tail water impacts from Onion Creek and allow the diversion to drain efficiently. This option would impact the golf course and therefore require modifications to the course alignment.
- **Channel Clearing** – Reducing the friction losses within a channel and immediate overbanks can be a hydraulically effective alternative to reduce flood elevations. However, such clearing can have significant environmental impacts and high maintenance and mitigation costs. Friction losses can be reduced by selective clearing of the channel and overbanks, including the removal of debris, underbrush, and small trees. Significant decreases in roughness coefficients near the Pinehurst area resulted in computed 1% ACE water surface elevation decreases between 0.1 and 2.0 feet. Although this alternative is somewhat effective it does not have the impact necessary to provide significant relief to properties in the 1% ACE floodplain. In addition, this alternative would require significant efforts to maintain the “cleared” channel and would significantly impact the riparian corridor along Onion Creek.
- **Remove Constrictions** – Localized increases in water surface elevations (head loss) along a creek exist where channel constrictions reduce the cross-sectional area (conveyance) of a channel. Typical man-made constrictions include encroachment of the channel due to development and roadway crossings. These constrictions ultimately raise water surface elevations along the creek. The properties along Champions Lane restrict the conveyance of Onion Creek in the Pinehurst area. Acquisition of Champions Lane properties including channel modification was simulated to evaluate resulting impacts to water surface elevations in this area. It was determined that increasing the channel capacity in the Pinehurst location does not have a significant benefit because majority of the channel conveyance is constricted along the southern bank of Onion Creek through this oxbow.
- **Channel Benching** – Similar to constriction removal, channel benching can be used to increase the cross-sectional area (conveyance) of a channel. To minimize US Army Corps of Engineers 404 Permitting requirements, channel benching was evaluated above Onion Creek’s estimated ordinary high water elevations. Channel benching in the Pinehurst area includes a large benched section on the north side of Onion Creek parallel to Pinehurst Drive, as well as, sloping of the eastern bank toward River Plantation Drive. It should be noted that channel benching alone through the Pinehurst area has minimal impact to the computed 1% ACE water surface elevations. These channel modifications must be combined with the downstream channel benching discussed for the Wild Dunes area for the computed 1% ACE water surface elevations to be significantly reduced. These improvements result in high velocities that could potentially be very erosive and therefore should be further evaluated in the subsequent analysis. Similar to the channel clearing, this alternative would require significant efforts to maintain the “cleared” channel and would significantly impact the riparian corridor along Onion Creek.

4030 West Braker Lane, Ste. 450
Austin, Texas 78759
(512) 777-4600
Fax (512) 252-8141

Wild Dunes Area

Approximately 27 structures in the Wild Dunes area are estimated to be inundated by the updated existing condition 1% ACE. In an effort to reduce flooding within the Wild Dunes area, the following hydraulic mitigation alternatives were conceptually evaluated.

- **Floodwall** – Due to the topography and location of the upper channel bank in the Wild Dunes area, alignment of the proposed floodwall would generally parallel Wild Dunes Drive and Shinnecock Hills Drive for approximately 3,400 feet. The average height of the wall would be approximately 5 feet with a maximum height of 12 feet. Construction of a floodwall in this location would also require the acquisition of about 31 structures along the eastern side of Wild Dunes Drive and the western side of Shinnecock Hills Drive. In addition, an internal drainage system is required to drain approximately 40 acres of local runoff. Given this alternative requires the acquisition of 31 structures, additional investigation will be required because there are only 27 structures with finished floor elevation below the 1% ACE and 54 properties inside the 1% ACE floodplain. The wall would need to be located as close to the existing structures as possible in order to minimize the height. Even if located immediately adjacent to the existing structures, the average height (and cost) of the wall would significantly increase.
- **Channel Clearing –** Reducing the friction losses within a channel and immediate overbanks can be an effective alternative to reducing flood elevations. However, such clearing can have significant environmental impacts and high maintenance and mitigation costs. Friction losses are reduced by selective clearing of the channel and overbanks, including the removal of debris, underbrush, and small trees. Significant decreases in roughness coefficients near the Wild Dunes area resulted in computed 1% ACE water surface elevation decreases between 0.7 and 2.0 feet. Although this alternative is relatively effective, it does not have the impact necessary to provide significant relief to properties in the 1% ACE floodplain. In addition, this alternative would require significant efforts to maintain the “cleared” channel and would significantly impact the riparian corridor along Onion Creek.
- **Remove Constrictions** – Head loss along a creek exists where channel constrictions reduce the cross-sectional area (conveyance) of a channel. Typical man-made constrictions include encroachment of the channel due to development or roadway crossings. These constrictions ultimately raise water surface elevations along the creek.
  - The properties along Wild Dunes Court restrict the conveyance of Onion Creek in the Wild Dunes area. Acquisition of Wild Dunes Court properties including channel modification was simulated to evaluate resulting impacts to water surface elevations in this area. It was found that increasing the channel capacity in this location does not have a significant benefit because the majority of the channel conveyance is restricted along the eastern bank of Onion Creek.
  - The River Plantation Drive crossing also restricts the conveyance of Onion Creek. The proposed River Plantation Drive improvements include excavating the channel to add conveyance under the River Plantation Drive bridge. Increasing the opening of this crossing not only benefits the Wild Dunes area, but also reduces the computed 1% ACE water surface elevations along River Plantation Drive and Interlachen Lane. Improvements to this crossing result in high velocities that could potentially be very erosive and therefore should be further evaluated in the subsequent preliminary engineering analysis.
- **Channel Benching** – Similar to constriction removal, channel benching can be used to increase the cross-sectional area (conveyance) of a channel. To minimize US Army Corps of Engineers Clean Water 404 Permitting requirements, channel benching was evaluated above Onion Creek’s estimated ordinary high water elevations. Channel benching in the Wild Dunes area includes a large benched section on the west side of Onion Creek parallel to Wild Dunes Drive, as well as, significant channel benching of the eastern bank from Wild Dunes Drive to Slaughter Lane. These improvements result in high velocities that could potentially be very erosive and therefore should be further evaluated in the subsequent analysis. Similar to the channel clearing, this alternative would require significant efforts to maintain the “cleared” channel and would significantly impact the riparian corridor along Onion Creek.

POTENTIAL MITIGATION ALTERNTIVES

Potential alternatives that best reduce Onion Creek structure flooding between IH-35 and Slaughter Lane are described below. This section documents the potential mitigation alternatives including high-level conceptual illustrations and preliminary opinions of probable costs. It should be noted that these conceptual mitigation concepts were simulated to remove the majority of the structural flooding within the two areas of concern. These mitigation concepts will be refined through subsequent preliminary

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(512) 777-4600
Fax (512) 252-8141

engineering analysis and coordination project Stakeholders. Final proposed mitigation alternatives will likely include a combination of alternatives. In addition, potential downstream impacts associated with these mitigation options will be evaluated during subsequent preliminary engineering analyses.

Non-Structural Alternatives

Non-Structural flood mitigation alternatives generally include floodplain management, construction and design regulations, and property acquisition. Of these alternatives the most effective means of reducing flood damages and improving public safety in previously developed areas is property acquisition.

- **Property Acquisition** – For this evaluation, the estimated cost of property acquisition includes real estate services, appraisals, acquisition costs, relocation/moving expenses, asbestos testing/abatement, demolition, and property management during the buyout process of single family residential structures inundated by the computed 1% ACE floodplain. The opinion of probable cost of property acquisition for 120 properties in the Pinehurst area is approximately $71 million and for 27 properties in the Wild Dunes area is approximately $20 million.

Structural Alternatives

Structural alternatives excluding channel modifications include: detention, diversions, levees, and floodwalls. Based on the evaluation of mitigation alternatives discussed above, the most effective independent structural alternatives for reducing flooding between IH-35 and Slaughter Lane include detention and floodwalls as follows:

- **Centex West Pond** – Detention in the Upper Onion watershed (Hays County) is used to temporarily detain flood waters for later release back into Onion Creek. Peak discharges of frequency events greater than the 4% (25-year) ACE are diverted into the Centex West Pond through a 150 feet wide excavated diversion channel. Diverted floodwaters then fill the Centex West Pond storing approximately 5,700 acre-feet. The maximum water pool in the Centex West Pond (given the current extent of mining operations) would have an approximate footprint of 4,700 feet by 1,500 feet with a maximum depth of 57 feet to the pond outlet pipes. Water from the pond would slowly be released back into Onion Creek through double 48-inch pipes. Since the existing quarry is deeper than the flowline of Onion Creek, there will be some flood water remaining in the pond that will need to be pumped. In addition, special provisions and environmental permitting will be required at the outlet to Onion Creek. As noted above, construction of an offline detention pond at this location would require negotiations with the property owner as well as the quarry operator to allow for disruptions to mining operations during and after flood events.

  The preliminary simulations of this pond indicate that peak discharges through the Pinehurst and Wild Dunes area could be reduced as much as 10%. This 10% reduction in peak discharges results in water surface elevation decreases between 0.5 and 1.5 feet. This detention alternative in combination with other mitigation alternatives could be very beneficial. The opinion of probable cost for the Centex West Pond is approximately $34 million.

- **Floodwalls –** Floodwalls would provide protection for the flood prone areas. However, the construction of these floodwalls would require property acquisition of multiple structures, impacts to the neighborhood and golf course, and a substantial internal drainage systems to drain local runoff. Property acquisition for construction of the floodwall may require non-voluntary (eminent domain) property acquisition.
  - *Pinehurst Area:* A floodwall was simulated to parallel Pinehurst Drive for approximately 6,200 feet. The wall has an average height of 7 feet with a maximum height of 16 feet. The opinion of probable cost for the Pinehurst Floodwall is approximately $49 million. This project protects approximately 74 structures from the 1% ACE in addition to the 46 structures that are removed from the 1% ACE through the associated property acquisition.
  - *Wild Dunes Area:* A floodwall was simulated to generally parallel Wild Dunes Drive and Shinnecock Hills Drive for approximately 3,400 feet. The wall has an average height of 5 feet with a maximum height of 12 feet. The opinion of probable cost for the Wild Dunes Floodwall is approximately $31 million. This project protects approximately 9 structures from the computed 1% ACE in addition to the 18 structures removed from the 1% ACE through the associated property acquisition.

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Austin, Texas 78759
(512) 777-4600
Fax (512) 252-8141

Channel Alternatives

Channel modification alternatives generally include channel clearing, channel benching, channel stabilization and crossing improvements. Following the individual evaluation of channel modifications, it was found that the most effective alternative was a combination of channel improvements.

- **Channel Clearing –** The alternative for channel clearing included reducing roughness coefficients of the immediate Onion Creek channel from a naturally vegetated channel to a maintained channel clear of underbrush and small trees. Similarly the Onion Creek overbanks would be cleared to a maintained overbank clear of underbrush and small trees. Selective clearing of the channel was simulated along 4.4 miles of Onion Creek between IH-35 and Slaughter Lane. The average width of channel clearing was approximately 900 feet. Significant decrease in roughness coefficients near the Pinehurst area resulted in computed 1% ACE water surface elevation decreases between 0.1 and 2.0 feet and between 0.7 and 2.0 feet in the Wild Dunes area. Although this alternative is somewhat effective, it does not have the impact necessary to provide significant relief to all properties in the 1% ACE floodplain. In addition, this alternative would require significant efforts to maintain the "cleared" channel and overbanks and would significantly impact the riparian corridor along Onion Creek. The opinion of probable cost for channel clearing is approximately $12 million.
- **Channel Improvements** – A conceptual evaluation of the combined channel alternatives included channel clearing, channel benching, and crossing improvements to the River Plantation Drive crossing. Channel benching in the Pinehurst area would include a large benched section on the north side of Onion Creek parallel to Pinehurst Drive, as well as, sloping of the eastern rock bank toward River Plantation Drive. Channel benching in the Wild Dunes area would include a large benched section on the west side of Onion Creek parallel to Wild Dunes Drive, as well as, significant channel benching of the eastern rock bank from Wild Dunes Drive to Slaughter Lane. Once excavated, the channel would be revegetated with a low grass to maintain a "cleared" channel. Maintaining the modified channel in a "cleared" channel condition will require significant commitment to long term maintenance. River Plantation Drive improvements include increasing the capacity of the crossing to reduce the existing channel constriction and prevent overtopping of the roadway. For this analysis, the bridge opening was increased to the current south side bridge abutment. Additionally, the proposed improvements to increase the capacity of this crossing result in high velocities that could potentially be erosive and therefore should be further evaluated in the subsequent preliminary engineering analysis. Although this alternative is effective, it does not provide sufficient benefits to remove all impacted properties in the 1% ACE floodplain. This alternative resulted in computed 1% ACE water surface elevation decreases between 1.4 and 2.7 feet in the Pinehurst area and between 2.5 and 4.0 feet in the Wild Dunes area. The channel improvement alternative would significantly impact the riparian corridor as well as the golf course. The opinion of probable cost for the combined channel improvements is approximately $74 million.

As noted previously, the preliminary results from the updated existing development condition 1% ACE were used as the baseline for this conceptual flood mitigation analysis. During the subsequent preliminary engineering evaluation of alternatives, the final fully developed condition 1% ACE flows will be used. In addition, these mitigation concepts will be further refined through coordination with project Stakeholders and additional detailed analysis.

ATTACHMENTS:

Illustrations

- Potential Centex West Pond
- Potential Floodwall Locations
- Potential Channel Clearing
- Potential Channel Improvements

Opinion of Probable Construction Costs

- Property Acquisition (Pinehurst and Wild Dunes Areas)
- Centex West Pond
- Floodwall (Pinehurst and Wild Dunes Areas)
- Channel Clearing
- Channel Improvements

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Austin, Texas 78759
(512) 777-4600
Fax (512) 252-8141

ILLUSTRATIONS

Potential Centex West Pond
Potential Floodwall Locations
Potential Channel Clearing
Potential Channel Improvements

ONION CREEK

DIVERSION CHANNEL FROM ONION CREEK

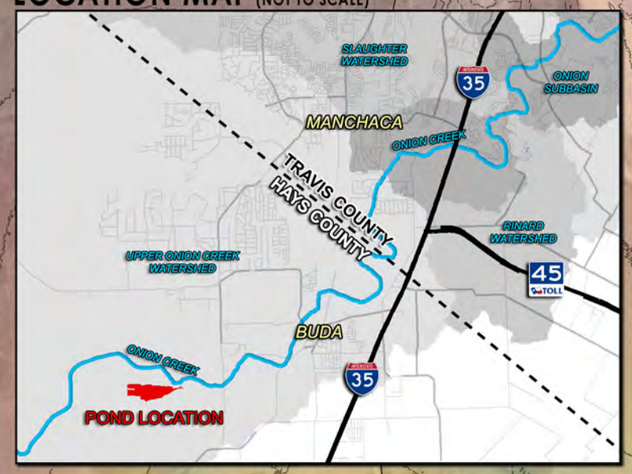
ONION CREEK

POND OUTLET (UNDERGROUND PIPE)

MAXIMUM WATER POOL

NEW CONSTRUCTION ROADWAY

LOCATION MAP (NOT TO SCALE)



0 250 500 750 1,000 1,500 2,000 FEET

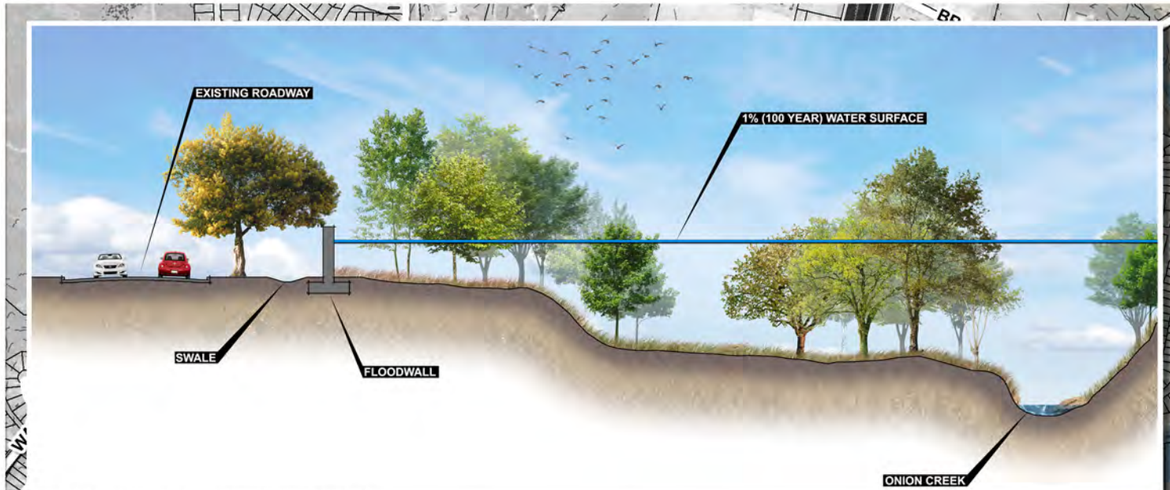
ONION CREEK FLOODPLAIN

POTENTIAL CENTEX WEST POND
CITY OF AUSTIN

NORTH

HALFF

MARCH, 2015 AVO 274908



TYPICAL SECTION

ONION CREEK

SLAUGHTER

WILD DUNES

POTENTIAL FLOODWALL

WILD DUNES AREA

SLICKROCK

BRAE MAR

ROYAL LYTHAM

INNISBROOK

COSTA

MUIRFIELD

CHERYL LYNN

FLOODPLAIN

INTERSTATE 35

FARM 1626 ROAD

CONROY

BAL TUSROL

HAZELTINE

LEGENDS

CROWN COLONY

PEBBLE BEACH

PINEHURST

PRESTON TRAILS

POINT CLEAR

ONION CREEK

INTER LACHEN

PRAIRIE DUNES

RIVER PLANTATION

POTENTIAL FLOODWALL

PINEHURST AREA

TAMARISK

MERION CRICKET

INDIAN WELLS

COUNTY DOWN

BRADSHAW

OLD LOCKHART

ONION CREEK

0 0.125 0.25 0.50 0.75 1 MILE

ONION CREEK FLOODPLAIN

POTENTIAL FLOODWALL LOCATIONS
CITY OF AUSTIN

NORTH

HALFF

MARCH, 2015 AVO 274908

TYPICAL SECTION

ONION CREEK

CLEARING OF LESS DENSE AREA

CLEARING OF MORE DENSE AREA

FLOODPLAIN

WILD DUNES AREA

PINEHURST AREA

WILD DUNES

SLICKROCK

BRAE MAR

ROYAL LYTHAM

INNISBROOK

LA COSTA

BAL TUSROL

PEBBLE BEACH

LEGENDS

CROWN COLONY

PINEHURST

PRESTON TRAILS

ONION CREEK

POINT CLEAR

TAMARISK

MERION CRICKET

INDIAN WELLS

COUNTY DOWN

INTER LACHEN

PRAIRIE DUNES

RIVER PLANTATION

BRADSHAW

OLD LOCKHART

CHERYL LYNN

SLAUGHTER

OLD SAN ANTO

CONROY

INTERSTATE 35

FARM 1626 ROAD

0 0.125 0.25 0.50 0.75 1 MILE

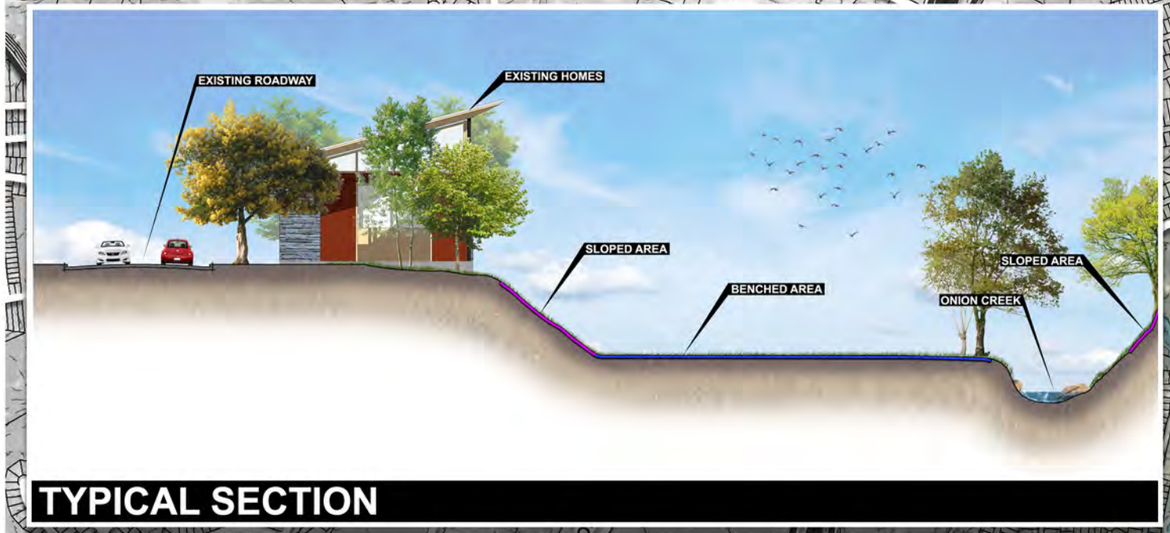
NORTH

HALFF

MARCH, 2015 AVO 27490B

ONION CREEK FLOODPLAIN

POTENTIAL CHANNEL CLEARING
CITY OF AUSTIN



TYPICAL SECTION

ONION CREEK

BENCHED AREA (TYP.)

SLOPED AREA (TYP.)

WILD DUNES

WILD DUNES AREA

BRAE MAR

ROYAL LYTHAM

INNISBROOK

LA COSTA

SLICKROCK

CHERYL LYNN

SLAUGHTER

FLOODPLAIN

OLD SAN ANTO

INTERSTATE 35

FARM 1626 ROAD

CONROY

BAL TUSROL

PEBBLE BEACH

CROWN COLONY

LEGENDS

PINEHURST

PRESTON TRAILS

ONION CREEK

POINT CLEAR

TAMARISK

PINEHURST AREA

MERION CRICKET

INDIAN WELLS

INTERLACHEN

PRAIRIE DUNES

RIVER PLANTATION

COUNTY DOWN

BRADSHAW

OLD LOCKHART

ONION CREEK

0 0.125 0.25 0.50 0.75 1 MILE

ONION CREEK FLOODPLAIN

POTENTIAL CHANNEL IMPROVEMENTS
CITY OF AUSTIN

NORTH

HALFF

MARCH, 2015 AVO 274908

HALFF
TBPE Firm# F-312

4030 West Braker Lane, Ste. 450
Austin, Texas 78759
(512) 777-4600
Fax (512) 252-8141

OPINION OF PROBABLE CONSTRUCTION COSTS

Property Acquisition (Pinehurst and Wild Dunes Areas)
Centex West Pond
Floodwall (Pinehurst and Wild Dunes Areas)
Channel Clearing
Channel Improvements

HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 3/1/2016
AVO: 27490B
PROJECT: City of Austin Onion Creek Floodplain Modeling and Mapping Phase 2 - Risk Identification & Mitigation
Alternative: Onion Creek Property Acquisition

PINEHURST AREA

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Property Acquisition, Pinehurst area (120 properties)	LS	$63,100,000	1	$63,100,000
				CONTINGENCY	$7,900,000
				PROJECT GRAND TOTAL	$71,000,000
OPERATION & MAINTENANCE					
2	Mowing (medium terrain) (biannual)	SF	$0.00525	3,659,040	$19,210
				ANNUAL O&M COST	$19,210

WILD DUNES AREA

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Property Acquisition, Wild Dunes area (27 properties)	LS	$17,100,000	1	$17,100,000
				CONTINGENCY	$2,100,000
				PROJECT GRAND TOTAL	$19,200,000
OPERATION & MAINTENANCE					
2	Mowing (medium terrain) (biannual)	SF	$0.00525	784,080	$4,116
				ANNUAL O&M COST	$4,116

Note: Estimates include all costs associated with property acquisition (including real estate services, appraisals, acquisition costs, relocation/moving expenses, asbestos testing/abatement, demolition, and property management during the entire process). Estimates also include a contingency to account for potential real estate market changes in the future and if eminent domain is required.

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and the Engineer shall not be held liable to Owner or third party for any failure to accurately estimate the cost of the project, or any part thereof. Unit Prices are in current dollars and should be adjusted as required when schedule for project is determined.

HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 2/29/2016

AVO: 27490B

PROJECT: City of Austin Onion Creek Floodplain Modeling and Mapping Phase 2 - Risk Identification & Mitigation

ALTERNATIVE: Centex West Detention Pond

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and Grubbing	AC	$5,000	13	$65,000
2	Tree protection and mitigation	AC	$2,000	13	$26,000
3	Double outlet pipes (2 - 48")	LF	$250	7,000	$1,750,000
4	Boring of pipe (2 - 48")	LF	$1,000	7,000	$7,000,000
5	Headwall	EA	$50,000	2	$100,000
6	Channel connection at pond culvert outlet	EA	$150,000	1	$150,000
7	Channel Excavation for diversion	CY	$15	532,700	$7,990,500
8	Concrete Channel Lining (6-8")	CY	$70	7,900	$553,000
9	Energy dissipation structure for diversion	EA	$120,000	1	$120,000
10	Stockpiling and Placing Topsoil (4")	SY	$5	25,799	$128,995
11	Hydromulch Seeding	SY	$2	25,799	$51,598
12	Soil Retention Blankets	SY	$6	25,799	$154,794
13	Pilot channel in pond	LF	$25	4,500	$112,500
14	Care of Water	LS	$50,000	1	$50,000
15	Road Relocation (50' wide)	SY	$50	44,800	$2,240,000
16	Temporary Erosion and Sediment Control	LS	$350,000	1	$350,000
17	Mobilization	LS	$1,000,000	1	$1,000,000
				SUBTOTAL	**$21,842,387**
				CONTINGENCY (30%)	**$6,552,716**
				TOTAL PROJECT COST	**$28,395,103**
18	Engineering and Survey Fees (15%)	LS	$4,260,000	1	$4,260,000
19	Regulatory Permitting (3%)	LS	$852,000	1	$852,000
				PROJECT GRAND TOTAL	**$33,507,103**
OPERATION & MAINTENANCE					
20	Annual clearing and maintenance	LS	$20,000	1	$20,000
				ANNUAL O&M COST	**$20,000**

Note: Estimate excludes cost of land acquisition, Centex operation compensation, and protection, relocation, reconstruction of utilities.

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HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 2/29/2016

AVO: 27490B

PROJECT: City of Austin Onion Creek Floodplain Modeling and Mapping Phase 2 - Risk Identification & Mitigation

ALTERNATIVE: Flood Protection Wall in Pinehurst area

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and Grubbing w/ tree removal	AC	$10,000	2	$20,000
2	Tree protection and mitigation	AC	$2,000	6	$11,386.59
3	Flood wall	LF	$750	6,200	$4,650,000
4	Form liner, stain, and seal for wall	LF	$150	6,200	$930,000
5	Internal Drainage System	LS	$1,000,000	1	$1,000,000
6	Rock Riprap	CY	$150	9,200	$1,380,000
7	Stockpiling and Placing Topsoil (4")	SY	$5	27,556	$137,778
8	Hydromulch Seeding	SY	$2	27,556	$55,111
9	Soil Retention Blankets	SY	$6	27,556	$165,333
10	Temporary Erosion and Sediment Control (5%)	LS	$418,000	1	$418,000
11	Neighborhood Street Maintenance	LS	$400,000	1	$400,000
12	Neighborhood Safety and Security	LS	$100,000	1	$100,000
13	Mobilization (12%)	LS	$1,113,000	1	$1,113,000
				SUBTOTAL	**$10,380,609**
				CONTINGENCY (30%)	**$3,114,183**
				TOTAL PROJECT COST	**$13,494,791**
14	Engineering and Survey Fees (15%)	LS	$2,025,000	1	$2,025,000
15	Regulatory Permitting (7%)	LS	$945,000	1	$945,000
16	Land Acquisition	LS	$32,100,000	1	$32,100,000
				PROJECT GRAND TOTAL	**$48,564,791**
OPERATION & MAINTENANCE					
17	Mowing (medium terrain) (biannual)	SF	$0.00525	496,000	$2,604
18	Annual inspection and maintenance	LS	$20,000	1	$20,000
				ANNUAL O&M COST	**$22,604**

Note: Estimate excludes cost of protection, relocation, and reconstruction of utilities.

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HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 2/29/2016

AVO: 27490B

PROJECT: City of Austin Onion Creek Floodplain Modeling and Mapping Phase 2 - Risk Identification & Mitigation

ALTERNATIVE: Flood Protection Wall in Wild Dunes area

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and Grubbing w/ tree removal	AC	$10,000	1.3	$13,000
2	Tree protection and mitigation	AC	$2,000	3	$6,244.26
3	Flood wall	LF	$750	3,400	$2,550,000
4	Form liner, stain, and seal for wall	LF	$150	3,400	$510,000
5	Internal Drainage System	LS	$500,000	1	$500,000
6	Rock Riprap	CY	$150	5,100	$765,000
7	Stockpiling and Placing Topsoil (4")	SY	$5	15,111	$75,556
8	Hydromulch Seeding	SY	$2	15,111	$30,222
9	Soil Retention Blankets	SY	$6	15,111	$90,667
10	Temporary Erosion and Sediment Control (5%)	LS	$228,000	1	$228,000
11	Neighborhood Street Maintenance	LS	$400,000	1	$400,000
12	Neighborhood Safety and Security	LS	$100,000	1	$100,000
13	Mobilization (12%)	LS	$633,000	1	$633,000
				SUBTOTAL	**$5,901,689**
				CONTINGENCY (30%)	**$1,770,507**
				TOTAL PROJECT COST	**$7,672,195**
14	Engineering and Survey Fees (15%)	LS	$1,151,000	1	$1,151,000
15	Regulatory Permitting (7%)	LS	$538,000	1	$538,000
16	Land Acquisition	LS	$22,100,000	1	$22,100,000
				PROJECT GRAND TOTAL	**$31,461,195**
OPERATION & MAINTENANCE					
17	Mowing (medium terrain) (biannual)	SF	$0.00525	272,000	$1,428
18	Annual inspection and maintenance	LS	$20,000	1	$20,000
				ANNUAL O&M COST	**$21,428**

Note: Estimate excludes cost of protection, relocation, and reconstruction of utilities.

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HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 2/29/2016

AVO: 27490B

PROJECT: City of Austin Onion Creek Floodplain Modeling and Mapping Phase 2 - Risk Identification & Mitigation

Alternative: Onion Creek Channel Clearing

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Selective Clearing - Less dense	AC	$6,000	205	$1,230,000
2	Selective Clearing - More dense	AC	$10,000	190	$1,900,000
3	Tree protection and mitigation	AC	$2,000	395	$790,000
4	Hydromulch Seeding	SY	$2	400,510	$801,020
5	Soil Retention Blankets	SY	$6	400,510	$2,403,060
6	Care of Water	LS	$20,000	1	$20,000
7	Temporary Erosion and Sediment Control (2%)	LS	$143,000	1	$143,000
8	Mobilization (12%)	LS	$365,000	1	$365,000
				SUBTOTAL	$7,652,080
				CONTINGENCY (30%)	$2,295,624
				TOTAL PROJECT COST	$9,947,704
9	Management, engineering, and survey fees (10%)	LS	$995,000	1	$995,000
10	Regulatory Permitting (2.5%)	LS	$249,000	1	$249,000
				PROJECT GRAND TOTAL	$11,191,704
OPERATION & MAINTENANCE					
11	Mowing (medium terrain) (biannual)	SF	$0.00525	17,859,600	$93,763
12	Mowing (steep terrain) (biannual)	SF	$0.05	10,977,120	$548,856
13	Post flood event debris removal (20% annual chance)	LF	$16	23,240	$362,544
				ANNUAL O&M COST	$1,005,163

Note: Estimate excludes cost of easement acquisition and cost of protection, relocation, and reconstruction of utilities

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HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 2/29/2016

AVO: 27490B

PROJECT: City of Austin Onion Creek Floodplain Modeling and Mapping Phase 2 - Risk Identification & Mitigation

Alternative: Onion Creek Channel Improvements

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Selective Clearing - Less dense	AC	$6,000	238	$1,428,000
2	Selective Clearing - More dense	AC	$10,000	190	$1,900,000
3	Tree protection and mitigation	AC	$2,000	428	$856,000
4	Channel Excavation	CY	$10	1,485,002	$14,850,016
5	Channel Excavation (rock)	CY	$20	1,265,001	$25,300,028
6	Rock riprap	CY	$150	8,254	$1,238,083
7	Hydromulch Seeding	SY	$2	374,019	$748,039
8	Soil Retention Blankets	SY	$6	374,019	$2,244,116
9	Care of Water	LS	$50,000	1	$50,000
10	Relocation of Water Quality Pond	LS	$200,000	1	$200,000
11	Temporary Erosion and Sediment Control (2%)	LS	$972,000	1	$972,000
12	Mobilization (12%)	LS	$2,490,000	1	$2,490,000
				SUBTOTAL	**$52,276,281**
				CONTINGENCY (30%)	**$15,682,884**
				TOTAL PROJECT COST	**$67,959,165**
13	Engineering and Survey Fees (5%)	LS	$3,398,000	1	$3,398,000
14	Regulatory Permitting (2.5%)	LS	$1,699,000	1	$1,699,000
				PROJECT GRAND TOTAL	**$73,056,165**
OPERATION & MAINTENANCE					
15	Mowing (medium terrain) (biannual)	SF	$0.00525	20,734,560	$108,856
16	Mowing (steep terrain) (biannual)	SF	$0.05	10,977,120	$548,856
17	Post flood event debris removal (20% annual chance)	LF	$16	23,240	$362,544
				ANNUAL O&M COST	**$1,020,256**

Note: Estimate excludes cost of easement acquisition and cost of protection, relocation, and reconstruction of utilities

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