Staff Report

FLOOD MITIGATION STUDY
REVIEW OF ADDITIONAL ALTERNATIVES

October 29, 2013

BACKGROUND:

On April 12, 2013, HDR Engineers gave a presentation of their work on the Ames Flood Mitigation Study to the City Council in a workshop format, including an evaluation of a series of 11 mitigation alternatives (See Attachment 1). **It appeared from the study that the three conveyance alternatives (clearing the Squaw Creek channel from Lincoln Way to South Duff; reshaping the channel at South Duff; and improvements to the Highway 30 bridge) yielded the greatest flood mitigation benefits per dollar expended**. **At that meeting, Council specifically directed to see alternatives that include a combination of the most beneficial upstream flood storage strategies and levees.**

In response to this Council directive, this staff report contains three combination alternatives for the Council to consider. See Attachment 2. Attachment 3 shows for comparison the stand-alone mitigation alternatives from the April workshop that went in to the combination alternatives.

- **Combination Alternative 1: Lengthen Highway 30 Bridge and Reshape Squaw Creek Channel**.

  Construction Cost Estimate: $ 4,720,000 Reshaping
  $ 7,740,000 Bridge
  $12,460,000 Total

  Benefit/Cost Ratio: 3.50

  This alternative combines two discrete elements. The first is to lengthen the US Highway 30 Bridge over the South Skunk River. The second is to make improvements to the shape of the Squaw Creek Channel immediately upstream and also downstream of the South Duff Avenue Bridge.

  The improvement to the US Highway 30 Bridge was modeled as a 430' extension of the west of the existing bridge deck. When the City rebuilt SE 16th Street, the portion to the west of the Skunk River was intentionally designed to go under water in a flood event that exceeds the 2% chance ("50 year" flood), and no additional modification to SE 16th Street would be needed.

Staff discussed the likely timing for this bridge lengthening project with the Iowa Department of Transportation. The bridges on US 30 were constructed nearly 50 years ago in 1964. At this time, they are not scheduled for replacement in IDOT's current 5-year program and IDOT does not have a formal long-range plan for bridge replacements. Given the bridges are 50 years old, IDOT reports they would likely replace the structures within the next 20 years. At the time of replacement, IDOT does plan on lengthening the structures. While the actual configuration of the structures will depend on studies conducted at that point in time, IDOT currently envisions that the structures would be lengthened approximately 400 feet to the west.

The second element, channel modification, involves reconstruction of the Squaw Creek Channel into a more hydraulically efficient trapezoidal cross-section. This modification would extend approximately 2,000 feet upstream and also downstream of the South Duff crossing over the Creek. This alternative would have a pronounced impact on the 1% chance ("100-year" flood) elevations in the immediate vicinity of South Duff Avenue, lowering the water surface elevation by an estimated 1.4 feet. But the benefit would fall off rapidly upstream, with little to no impact realized at Lincoln Way. However, Iowa State University and CyRide have already undertaken significant mitigation measures for structures in this area.

- **Variation on Alternative 1: Lengthen Highway 30 Bridge and Remove Vegetation from Squaw Creek Channel**

  Construction Cost Estimate: $ 2,940,000 Clear Vegetation
  $ 7,740,000 Bridge
  $10,680,000 Total

  Benefit/Cost Ratio: Not Calculated

  This alternative was not evaluated by the consultant (thus, no Benefit/Cost Ratio was determined), but appears to staff to offer a possible variation to Combination Alternative 1. This variation would be to combine the US Highway 30 bridge lengthening with clearing vegetation along the Squaw Creek Channel in an approximately 300' wide swath (150' each side of the center of the channel – See Attachment 4), beginning at Lincoln Way and continuing downstream to the confluence with Skunk River. This work is anticipated to result in an approximate 2.1 foot reduction in the 1% chance ("100-year") flood elevation along this entire length of the creek.

  This alternative offers a lower construction cost than Combination Alternative 1 above. The conclusion in the consultant's report that this option is "free of major environmental impacts" is based on there being no anticipated hurdles such as threatened and endangered species, large contaminated parcels of land involved, wetlands that couldn't be easily mitigated, or insurmountable permitting

requirements. **However, staff believes that the Council should be prepared for possible negative feedback should this alternative be pursued, simply due to the large quantity of vegetation that would be removed.**

- **Combination Alternative 2: Lengthening Highway 30 Bridge, Reshape Squaw Creek Channel PLUS Levees**.

Construction Cost (with 100-yr Levees):	$ 7,740,000 Bridge $ 4,720,000 Reshaping $10,900,000 100-yr Levees $23,360,000 Total
Benefit/Cost Ratio:	1.85
Construction Costs (with 500-yr Levees):	$ 7,740,000 Bridge $ 4,720,000 Reshaping $13,000,000 500-yr Levees $25,460,000 Total
Benefit/Cost Ratio:	1.72

This alternative includes both elements from Combination Alternative 1, paired with a levee system. Three individual levee walls are envisioned. One would start at Stuart Smith Park on the north side of Squaw Creek and run east, then cross South Duff Avenue and run north behind the Super Wal-Mart and Target properties, then cross East Lincoln Way and tie in to the railroad embankment. A second levee would run on the east side of the Skunk River, starting at the railroad embankment and running south along the edge of the flood plain to Highway 30. A third small levee was included to protect the commercial establishments and mobile home parks on Duff Avenue south of Squaw Creek. (See Attachment 5.)

Two different elevations were modeled for the levees. The first would construct levees to an elevation that is three feet above the updated 100-year flood elevation as calculated by the consultant. The second would construct the levees to an elevation that matches the 500-year flood elevation as calculated by the consultant.

It should be noted that levees do not actually lower the elevation of flood waters; they simply keep the flood waters away from the protected properties. When levees are installed, some means of moving trapped storm water runoff from the protected side of the levee is needed. In this case, storm water pumping stations would be required to move storm water past the flood levees and into the rivers. These pump stations would be costly both to construct and to operate.

As a stand-alone alternative, both levee options have a Benefit/Cost Ratio (BCR) of less than 1.0, meaning they are not cost effective. When combined with Alternative 1, the levee options do have a Benefit/Cost Ratio of greater than 1.0, but results in a doubling of the capital cost for a comparatively small additional reduction in the Estimated Annual Damage Reduction.

- **Combination Alternative 3: Cost-effective Regional Storage**.

  Construction Cost Estimate: $21,900,000
  Benefit/Cost Ratio: 2.16

  This alternative does not build on either of the previous two alternatives. Instead, it looks to slow the flow of flood waters by constructing two regional storage basins upstream.

  In the Regional Storage Alternative presented to Council in April 2013 consisted of 14 regional storage basins, at an estimated construction cost of $145,000,000. These consisted of a series of tributary detention and smaller main stem dams. Based on direction from the City Council, the consultants reviewed this alternative to identify which of the individual storage basins contribute the greatest degree of reduction in flood levels experienced in Ames.

  Combination Alternative 3 includes just two storage basins. One would be located on Skunk River north of Ellsworth, and one would be located on Squaw Creek just outside the Ames city limits. (See Attachment 6.) This alternative would provide the greatest Estimated Annual Damage Reduction of any of the Combination Alternatives. The recommended placement of the Skunk River basin would not increase the flooding potential for any other communities; in fact, it would provide increased protection for Ellsworth and Story City as well as Ames.

  While having a comparatively high construction cost estimate, it still has a Benefit/Cost Ratio of 2.16, significantly greater than 1.0. Not factored into the economic evaluation were potential recreational benefits such structures may offer. However, the multijurisdictional nature of this strategy would significantly lengthen the time required to fully implement it. While the consultant's report notes that this has smaller environmental impacts than the larger storage options, it could have a substantial impact on Onion Creek. A previous study performed by the City as a part of a sewer routing study noted this as high quality woodlands, and the Council could anticipate possible negative feedback should this alternative be pursued due to the impact on Onion Creek.

A summary of the Combination Alternatives that include a comparison of the construction costs, hydraulic benefits, estimated annual reduction in property damage, a

calculated Benefit/Cost Ratio, relative annual operating cost, and other key aspects is attached as Attachment 2.

FUNDING CONSIDERATIONS

The projects brought forward in the study would require a substantial investment in the long-term protection of the community, and funding strategies are an important consideration when weighing which may be worth pursuing. Below are some high-level considerations for the most frequently used funding sources for flood mitigation projects. It is important to remember that the availability of grant funding and grant eligibility requirements can vary from year to year.

- **Funding Cycle.** The federal funding cycle typically begins in May. That is when communities would learn for sure what dollar amounts are available and how the grant awards would be determined. The submittal deadline for applications is usually mid-October. Communities then would learn in December if their application was successful; if it was, the funds are generally available by February.

- **Flood Mitigation Assistance Grants (FMA).** This is a FEMA grant program. The usual criterion is that the proposed project must provide a benefit for repetitive loss properties. This past year a requirement was included that at least some of the benefitted properties were flood insurance policy holders. This program has no maximum dollar cap on the grant award, and provides a 75% federal share and a 25% local match.

- **Pre-disaster Mitigation (PDM) Grants.** This is also a FEMA grant program, and is intended for both hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. This grant program has a $3,000,000 cap and also provides a 75% federal share and a 25% local match.

- **Local Matches.** In general, local matching funds can come from any source other than the federal government.

- **Eligible Projects.** Both grant programs define eligible applicants as including states, local governments, and Indian tribes or tribal organizations. It is not yet clear whether either of these two programs could be used to help fund the improvements to the Highway 30 bridge, as it is a federal highway. An inquiry has been made to the regional FEMA office to see how a grant application that included the bridge project might be viewed.

  FEMA grants are intended to be one-time projects that reduce the potential for future emergency assistance. As such, applications for projects that are viewed by FEMA as being “routine maintenance” would likely have a low likelihood for

success. For example, the suggested alternative for clearing vegetation from the Squaw Creek Channel could be determined to be "routine maintenance."

It also appears that FEMA would not fund levees, as a levee does not remove a property from the floodway. If levees were a mitigation strategy that the City desired to pursue, it would be more prudent to discuss the project in depth with the US Army Corps of Engineers, as they have the expertise and access to possible funding.

- **Properties Eligible for Protection.** FEMA would generally restrict its funding to improvements that project to the current effective FEMA 100-year flood. Should a community desire to protect to a level beyond that, supplemental funding sources would be needed.

  While an updated Flood Frequency Analysis (FFA) was performed as a part of the study, the scope of work requested of HDR did not include submission to FEMA for map revisions. The FFA did determine a statistical increase in the 100-year flood discharge flow of between 10 and 30%. A request to have the maps updated could have both positive and negative implications for the community. By increasing the size of the floodplain, additional property value could be considered when calculating the Benefit Cost Analysis for a project, which could increase a project's potential for FEMA funding. But it could also increase the amount of property that becomes undevelopable in the future. Requesting a FEMA map revision is a time consuming (multiple years) process.

- **Elements of a Successful Grant Application.** In talking with consultants familiar with the grant process, the following thoughts were shared about what it takes to prepare a successful application.

  - The application needs to include a compelling story. Historical examples of repetitive loss and major community-wide impacts are critical to convey the need for the project and the benefit the project would provide. Documentation in news accounts is a great way to convey the story.

  - The proposed projects must document a Benefit/Cost Analysis ratio of greater than 1.0. The higher the BCA score, the more beneficial the project. The BCA's for the projects included in the final list of alternatives all have BCA's that are substantially higher than 1.0, which increases the likelihood of a successful grant application. FEMA would require the BCA's to be recalculated using a specific FEMA protocol. The BCA's calculated by the consultant in the study very closely mirror the FEMA protocol, and are a strong indicator of the FEMA BCA scores.

  - Detailed hydrology and hydraulics are needed to show the pre- and post-mitigation conditions. The work performed by HDR as a part of this study is likely to be sufficient for the application process.

- Relationships with the regional FEMA office are critical. It was suggested that any applicant should meet at least one time (or more, depending on the complexity of the proposed project), to review a planned project with the regional FEMA staff prior to submittal. The regional office staff makes the determination on what applications are forwarded on to the national office for funding consideration, so making sure the regional staff understands the importance of a project is key.

- Successful applications generally include partnerships. Including others (chamber groups, neighborhood associations, other governmental bodies, etc.) on the grant application, even if they are not participating in the funding, helps to document that the proposed project has strong community support, and others can help an application's chances of funding.

- **Cost and timing for Preparing Grant Applications.** An appropriate budget for preparing a joint application for both a FMA grant and a PDM grant would be in the $75,000 to $100,000 range. A three month window should be allowed for preparing a quality proposal.

- **Other Grant Opportunities.** There are other smaller grant programs available. Generally, these other programs are not designed for projects of the scale as those currently being considered for Ames. However, they could provide some "complimentary" funding. For example, the Clean Water Act's Section 319 non-point source pollution grants could provide funding assistance for elements that provide water quality enhancements.

  Hazard Mitigation Grant Program funds become available immediately following a federal disaster declaration. The timeframe to act on these can be short. The funds are not restricted to just the recovery from the immediate disaster, but can be used to implement mitigation measures against future disasters.

  While not a grant, the Clean Water State Revolving Fund (SRF) offers 20-year, zero percent loans for watershed-based water quality improvements projects.

- **Local Funding.** If local funding is needed to match any of these projects, it would most likely need to come from General Obligation debt financing.

- **IDOT Funding of Highway 30 Bridge Modifications.** The estimated cost for the Highway 30 bridge improvement is $7,740,000. If Council wants to pursue an alternative that includes the US Highway 30 improvements, it could choose to:

  A. Request that IDOT accelerate the timing of the project.
  B. Wait for the IDOT to advance the project on their timeframe,
  C. Seek IDOT or federal funding opportunities to help accelerate this project,

D. Offer to help partially fund the project to accelerate the timing, or
E. Choose to fund the project entirely with local funds and proceed immediately.

STAFF COMMENTS

Council is not being asked to give direction tonight, but guidance will be needed by the second meeting in November if a project is to be shown in the next CIP.

Of the many engineering alternatives considered by the consultant, the option that appears to be the most attractive is Combination Alternative 1, which includes reshaping the Squaw Creek channel in the vicinity of South Duff Avenue in conjunction with modifications to the Highway 30 bridge. As compared to the clearing of vegetation included in the variation to Combination Alternative 1, this option provides a more permanent solution, is likely to be perceived as more environmentally acceptable, and would be eligible for federal funding assistance (thereby reducing the local contribution required).

It will be important to engage the services of an experienced grant writer to pursue FEMA grant opportunities. Should Council decide to pursue this Combination Alternative, staff would suggest that funds be designated in the first year of the CIP for securing the grant funding for the Squaw Creek reshaping, with design commencing in the second year contingent upon receiving a grant award, and with construction likely in the third year. Engaging the IDOT in discussions about the need to accelerate the Highway 30 bridge improvements will be critical to gaining the overall reductions in water surface elevations estimated by this study.

Combination Alternative 2 was seen as less attractive due to the substantially higher capital cost compared to Alternative 1 with only a slight improvement in the Estimated Annual Damage Reduction. Such levees may be seen as unattractive. In addition, the anticipated difficulty in securing FEMA grants for levees makes this alternative less desirable.

Combination Alternative 3 could be a viable alternative, as it provides the greatest Estimated Annual Damage Reduction of the final list of alternatives evaluated. However, it was seen as less attractive at this time because of the exceptional complexity of the multi-jurisdictional nature of the improvement, which likely means many years of discussion and negotiations before the physical improvement would be able to move ahead. **The regional storage basins could be considered along with other watershed improvements as part of the long-term flood mitigation and water quality collaboration between members of the Squaw Creek Watershed Management Authority and with other affected parties.** The City is a founding partner in the Squaw Creek Watershed Management Authority, which recently received a $160,000 grant to develop a comprehensive strategic plan that seeks viable alternatives to manage both water quality and quantity in the watershed.

In addition to engineered alternatives, Council may wish to consider possible regulatory changes to the current floodplain ordinance. The current regulations for new development prohibit construction in the floodway and require buildings to be three feet above the 100-year floodplain. As examples of the types of changes that might be considered, HDR identified the following:

- Prohibit all building within the 100-year floodplain
- Prohibit all building within the 500-year floodplain
- Regulation could be adjusted to the 100-year floodplain plus five feet
- Regulation could be adjusted to the 500-year floodplain plus three feet
- Redefine the floodway based on new modeling or a new recurrence interval
- Adopt a lifetime cumulative damage limit for properties in the floodplain

This is not an exhaustive list of possible revisions to the floodplain ordinance. HDR's report does not single out any particular change as being "recommended" but illustrates some of the possibilities that could be considered. **If Council is interested in discussing possible floodplain ordinance modifications, direction to staff to bring the subject to Council in a workshop setting would be appropriate.**

Finally, this study did not address needs related to localized urban flooding away from the rivers. Development of a post-construction storm water management ordinance is underway. This ordinance will look to manage both storm water quality and quantity, and to minimize the potential for localized flooding for future construction. That ordinance will be presented to Council on November 12.

ATTACHMENT 1: Summary of Alternatives Presented in the April 2013 Workshop

Excepted from City of Ames Flood Mitigation Study Council Workshop 3, HDR Engineers (April 16, 2013)

Alternative/Strategy		Description	Benefit Cost Analysis				Performance Criteria		
			Construction Costs	Annual Cost (including O&M)	Annual Benefits	BCR	Does it meet at least a 500-year level of protection?	Do the benefits outweigh the cost?	Is this alternative free of major environmental impacts?
Conservation Measures in the Watershed		The Conservation Measures in the Watershed alternative evaluates small detention sites that could contribute to flood reduction, and the construction of wetlands administered under the Iowa Department of Agriculture and Land Stewardship Conservation Reserve Enhancement Program.	$2,025,000	$122,230	$0	0.00	☒ (Note 1)	☒	☑
Centralized Flood Storage		The Centralized Storage alternative includes the evaluation of Squaw Creek Dry Detention facility and Ames Lake Reservoir.	$198,243,000	$11,966,036	$3,250,900	0.27	☑ (Note 2)	☒	☒
Regional Flood Storage		The Regional Flood Storage alternative includes the evaluation of 14 storage sites.	$145,339,000	$8,777,727	$3,217,000	0.37	☒ (Note 3)	☒	☒
Floodplain Storage		The Floodplain Storage alternative achieves additional floodplain storage by raising 3 roads by 5 feet, and modifying 3 bridges/culverts.	$41,000,000	$2,474,778	$2,786,900	1.13	☒ (Note 4)	☑	☒
Diversion 1		The Diversion 1 alternative includes diverting flood waters around Ames by diverting Squaw Creek at Cameron School Road to the Skunk River via the Ada Hayden Reservoir.	$49,243,000	$2,972,329	$3,042,700	1.02	☒ (Note 5)	☑	☒
Diversion 2		The Diversion 2 alternative includes diverting flood waters around Ames by diverting Squaw Creek upstream from Cameron School Road, to the Skunk River downstream from the Ames Municipal Airport.	$1,095,000,000	$66,094,687	$3,192,300	0.05	☒ (Note 6)	☒	☑
Conveyance Improvements	**Clear Channel**	The Conveyance Improvements alternative involves the clearing or excavating of river channel improvements and/or the removal of bridge obstructions.	$2,943,000	$177,641	$2,436,700	13.72	☒ (Note 7)	☑	☒
	US Hwy 30 Bridge Improvement		$7,740,000	$467,190	$2,097,300	4.49	☒ (Note 8)	☑	☑
	South Duff Bridge Improvement & Clear Channel		$4,715,000	$284,599	$2,086,900	7.33	☒ (Note 9)	☑	☑
Levee Protection 100-Year		The Levees alternatives evaluates protection to the 100-year flood level protecting property areas along Skunk River and Squaw Creek by constructing a levee (berm/floodwall) combination.	**Skunk River** $4,818,000 **Squaw Creek** $6,079,000	**Skunk River** $290,817 **Squaw Creek** $366,931	**Skunk River** $121,400 **Squaw Creek** $174,600	**Skunk River** 0.42 **Squaw Creek** 0.48	☒ (Note 10)	☒	☑
Levee Protection 500-Year		The Levees alternatives evaluates protection to the 500-year flood level protecting property areas along Skunk River and Squaw Creek by constructing a levee (berm/floodwall) combination.	**Skunk River** $5,333,000 **Squaw Creek** $7,668,000	**Skunk River** $321,902 **Squaw Creek** $462,844	**Skunk River** $198,100 **Squaw Creek** $174,600	**Skunk River** 0.62 **Squaw Creek** 0.38	☑	☒	☑

Key: ☑ = Yes; ☒ = No

ATTACHMENT 2: Summary of Combined Alternatives

Alternative	Construction Cost Estimate[1]	Hydraulic Benefit[2]		Estimated Annual Damage Reduction[3]	Benefit/ Cost Ratio[4]	Magnitude of Annual Operating Costs [5]	Key Aspects[6]
		Squaw Creek	Skunk River				
Combination Alternative 1 – Reshapes the Squaw Creek channel at South Duff, and extends the Highway 30 bridge 430'	$12,460,000	1.2'	1.2'	$2,630,000	3.50	Low	• Provides a greater Estimated Annual Damage Reduction than either element individually. • Provides a possibility of phased implementation (City does channel improvements early; waits for IDOT to make bridge improvements) • Lower BCR ratio suggests the incremental cost increase of doing both elements together is less cost effective than either as a stand-alone project; BCA is still quite attractive, though.
Variation of Combination Alternative 1 – Removes vegetation from Squaw Creek channel, and extends the Highway 30 bridge 430'	$10,680,000	Not evaluated by consultant					• Has a lower construction cost than Combination Alternative 1 (vegetation removal is less expensive than reshaping the channel) • Flood reduction extends further upstream than channel reshaping alternative. • Provides a possibility of phased implementation (City does channel improvements early; waits for IDOT to make bridge improvements) • Potential citizen concern due to quantity of vegetation to be removed
Combination Alternative 2 – Includes Combo Alt. 1 PLUS flood levees at either the 100-year or 500-year level	100-Yr Levees: $23,360,000	1.1'	1.2'	$2,700,000	1.85	High	• Levees do not reduce the water surface elevations (no increased Hydraulic Benefit), but do remove properties from damage; thus the increased Estimated Annual Damage Reduction for the same Hydraulic Benefit. • Has the lowest BCR rating, but is still > 1.0. • As stand-alone projects, levees have a BCR of < 1.0. • Levees may be perceived as unsightly.
	500-Yr Levees: $25,460,000	1.1'	1.2'	$2,750,000	1.72		
Combination Alternative 3 – Constructs two regional storage basins upstream of Ames	$21,900,000	1.4'	1.7'	$2,860,000	2.16	High	• Provides the greatest Estimated Annual Damage Reduction. • Potential for multi-jurisdictional partnership and funding. • Multi-jurisdictional nature could make implementation more difficult • Potential citizen concern over environmental impacts to Onion Creek

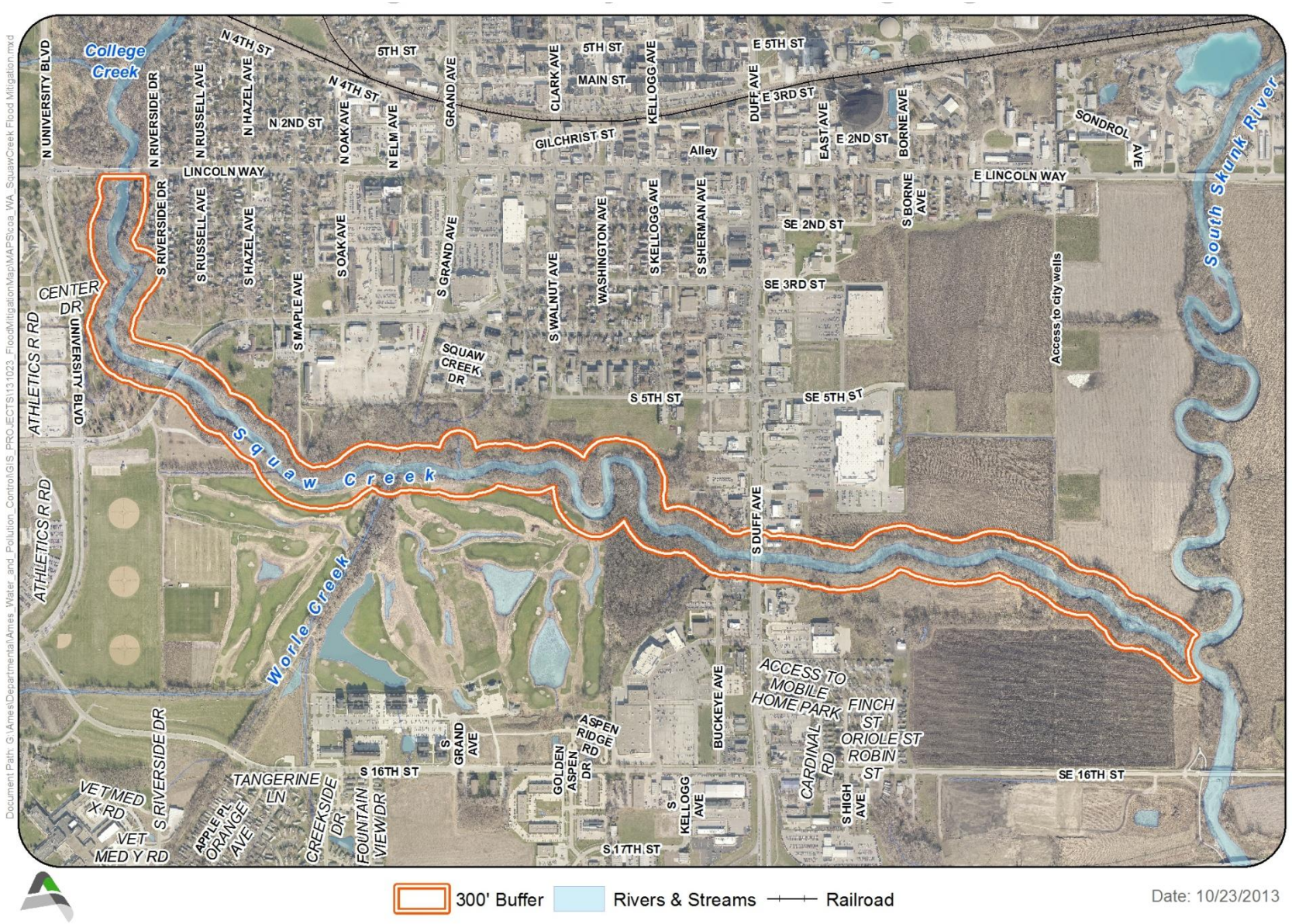
[1] –Cost estimates prepared at "concept screening or feasibility" level of detail can be reasonably expected to have an accuracy range of -25% to +50%. All estimates are prepared in 2013 dollars, rounded to 3 significant figures.
[2] – Hydraulic Benefit in this context is defined as a rough approximation of the reduction in water surface elevation in feet for the 100-yr storm at two fixed points: Squaw Creek just upstream of the South Duff Avenue crossing, and Skunk River just upstream of the S 16th Street crossing.
[3] – Estimated Annual Damage Reduction compares the estimate of damage that would occur if the project were to occur versus the damage that would occur if no projects were to occur. [4] – Benefit Cost Ratio is a ratio of the Estimated Annual Damage Reduction to the Total Annualized Cost of the project over 50 years, including both first costs and O&M. BCR of > 1.0 means the benefit exceeds the cost of the project.
[5] – Annual operating costs were estimated at 1.5% of the construction cost for calculating the BCR. For the purposes of comparing across alternatives, staff utilized a relative "High," "Medium," or "Low" rating.
[6] – Summarizes the key aspects of each alternative, with an emphasis on differences between the alternatives.

ATTACHMENT 3: Summary of Individual Alternatives Used in Combination Alternatives

Alternative	Construction Cost Estimate[1]	Hydraulic Benefit[2]		Estimated Annual Damage Reduction[3]	Benefit/ Cost Ratio[4]	Magnitude of Annual Operating Costs [5]	Key Aspects[6]
		Squaw Creek	Skunk River				
Reshape Squaw Creek Channel – Reshapes the Squaw Creek channel 2,000' either side of the South Duff crossing	$4,720,000	1.4'	0.0'	$2,200,000	7.73	Medium	• Has a smaller water surface elevation reduction on S Duff (major damage center) compared to the channel clearing alternative; and the benefit does not extend as far north. • Impacts a smaller segment of the river channel; may be seen as more environmentally friendly than channel clearing. • Would likely be eligible for FEMA grants
Clear Squaw Creek Channel – Removes vegetation 300 wide' along the channel from Lincoln Way to confluence with Skunk River	$2,940,000	2.1'	0.0'	$2,780,000	15.63	Medium	• Reduced water surface elevation benefit would be experienced along Squaw Creek from Lincoln Way to confluence with Skunk River. • No environmental prohibition anticipated, but may be perceived as environmentally unfriendly. • Would require ongoing maintenance to maintain the benefit • Likely not eligible for FEMA grants
US Highway 30 Bridge Lengthening – Extends bridge an additional 430' to the west	$7,740,000	0.0'	1.2'	$2,210,000	4.73	Low	• Project is currently shown in IDOT's planning horizon, but timing is not firm. • Possibility of IDOT funding entirely if City is willing to wait. • Potential that some contribution by City could accelerate IDOT timeline. • Eligibility for FEMA grants is unknown
Regional Storage – Series of tributary detention and smaller main stem dams	$145,000,000	5.5'	2.2'	$3,800,000	0.43	High	• Would impact over 7,000 acres, including 800 acres of wetland • Provides approximately "450-year flood" protection with a corresponding high level of damage reduction • With all storage sites taken as a whole, has a BCR of < 1
Flood Levees – Construct two flood levees; one on north side of Squaw Creek and west side of Skunk River; another east of Skunk River	100-Yr Levees: $10,900,000	0.0'	0.0'	$296,000	Skunk–0.26 Squaw–0.48	High	• Levees do not reduce the water surface elevations (no increased Hydraulic Benefit), but do remove properties from damage; thus the increased Estimated Annual Damage • Would require storm water pumping stations • Could be perceived as unsightly • FEMA typically does not fund levees; Army COE funding may be possible
	500-Yr Levees: $13,000,000	0.0'	0.0'	$328,000	Skunk–0.62 Squaw–0.38		

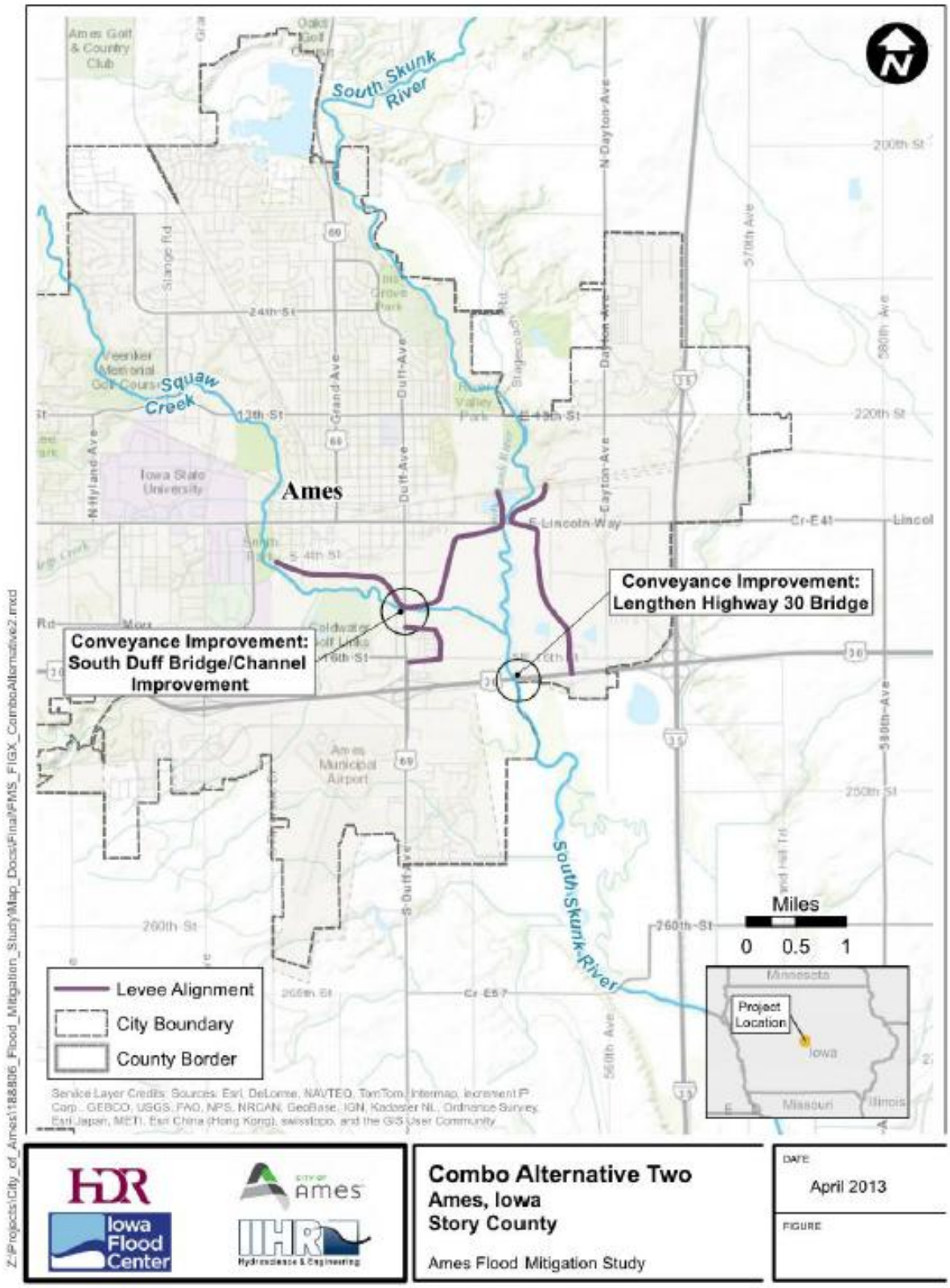
[1] –Cost estimates prepared at "concept screening or feasibility" level of detail can be reasonably expected to have an accuracy range of -25% to +50%. All estimates are prepared in 2013 dollars, rounded to 3 significant figures.
[2] – Hydraulic Benefit in this context is defined as a rough approximation of the reduction in water surface elevation in feet for the 100-yr storm at two fixed points: Squaw Creek just upstream of the South Duff Avenue crossing, and Skunk River just upstream of the S 16th Street crossing.
[3] – Estimated Annual Damage Reduction compares the estimate of damage that would occur if the project were to occur versus the damage that would occur if no projects were to occur. [4] – Benefit Cost Ratio is a ratio of the Estimated Annual Damage Reduction to the Total Annualized Cost of the project over 50 years, including both first costs and O&M. BCR of > 1.0 means the benefit exceeds the cost of the project.
[5] – Annual operating costs were estimated at 1.5% of the construction cost for calculating the BCR. For the purposes of comparing across alternatives, staff utilized a relative "High," "Medium," or "Low" rating.
[6] – Summarizes the key aspects of each alternative, with an emphasis on differences between the alternatives.

ATTACHMENT 4: Extent of Vegetation Removal



ATTACHMENT 5: Approximate Placement of Flood Walls

Excepted from City of Ames Flood Mitigation Study, HDR (2013)



ATTACHMENT 6: Approximate Extend of Regional Storage Basins

Excepted from City of Ames Flood Mitigation Study, HDR (2013)