US Army Corps of Engineers

HUNTINGTON DISTRICT, GREAT LAKES & OHIO RIVER DIVISION

FINAL DAM SAFETY MODIFICATION REPORT & ENVIRONMENTAL ASSESSMENT

ZOAR LEVEE & DIVERSION DAM

AN APPURTENANCE TO DOVER DAM
TUSCARAWAS RIVER, MUSKINGUM RIVER BASIN
TUSCARAWAS COUNTY, OHIO
NIDID: OH00003-ZL

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Zoar Levee & Diversion Dam,
FINAL DAM SAFETY MODIFICATION REPORT & ENVIRONMENTAL ASSESSMENT
EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE) has prepared the following Final Dam Safety Modification Report (DSMR) and Environmental Assessment (EA) for Zoar Levee & Diversion Dam.

Zoar Levee & Diversion Dam are located upstream of Dover Dam, in Tuscarawas County, Ohio on the Tuscarawas River. Zoar Levee & Diversion Dam is an appurtenant structure to Dover Dam. Zoar Levee & Diversion Dam was built in the 1930s to keep Zoar Village from having to be acquired for flowage easement to store flood waters behind Dover Dam.

Zoar Levee & Diversion Dam has been assigned a Dam Safety Action Classification (DSAC) 3 – Moderate Urgency for action project because the potential consequences to a unique and valued historical site from a failure of the project are unacceptable and the probability of failure of the project indicates a moderate urgency for action.

The Final DSMR documents the completion of a Dam Safety Modification Study (DSMS) to identify a risk management plan to reduce the unacceptable dam safety risks at Zoar Levee & Diversion Dam. The integrated EA documents the potential effects to the human environment that risk management alternatives may have, and how these potential effects were considered in identifying the risk management plan or the preferred action alternative (RMP/PAA).

The purpose and need for Federal action at Zoar Levee & Diversion Dam is to reduce and manage incremental risks that are above USACE Tolerable Risk Guidelines. Incremental risk is defined as risk (likelihood and consequences) associated with the presence of a flood risk management project that can be attributed to its breach prior or subsequent to overtopping, or due to component malfunction or misoperation.

An estimate of the existing risk condition indicates that the probability of inundation due to misoperation of the diversion dam or failure of the pumps was 1 in 5,080 chances each year; which is above USACE tolerable limits. The Future Without Action Condition (FWAC)/No Action scenario assumes these probabilities can be lowered below USACE tolerable limits through the execution of maintenance packages to rehabilitate the two oldest pumps and replacement of a restriction at the diversion channel. There is uncertainty associated with receiving sufficient funding to accomplish these activities.

While there is uncertainty concerning the nature of the geology which affects the certainty of estimates of breach probabilities, two potential failure modes (PFMs) (PFM 1A-2 & PFM 1A-4) at Zoar Levee are forecasted to present annual probabilities of breach prior to overtopping that are above USACE tolerable limits. Both PFM 1A-2 & PFM 1A-4 were concerned with events associated with backward erosion piping through pervious soils underlying Zoar Levee which could lead to a breach.

Risk estimates indicate that life-loss and economic consequences are relatively low in comparison to other projects in the USACE dam portfolio. Another consequence of the resulting inundations would be to the public value Zoar Village provides as a community, regionally important heritage tourism asset and nationally significant historical site. These consequences, combined with the annual probabilities of failure from PFM 1A-2 & PFM 1A-4, creates incremental risks that are above USACE Tolerable Risk Guidelines.

To address incremental inundation risks a wide variety of measures and alternatives were formulated and screened. The final array of action alternatives were designed to:

- Reduce the probability of backward erosion piping starting, by lowering the water pressures placed on the Village-Side of the levee; and/or
- Reduce the probability of any backward erosion piping that started on the Village-Side of the levee progressing underneath the levee and leading to a breach.

The five action alternatives are made up of combined options to treat each PFM specifically.

ACTION ALT	BALL FIELD OPTIONS (PFM1A-2)	PONDING AREA OPTIONS (PFM1A-4)
3A	Relief Wells & Internal Erosion Interception Trench (IEIT)	Filter
4A	Partial Weighted Filter Berm & Partial Relief Wells & IEIT	Filter
6A	IEIT	Filter
7A	Partial Length IEIT & Partial Weighted Filter Berm & No Action	Filter
10A	IEIT & Partial Weighted Filter Berm	Filter

Taking no action was also carefully considered and compared against each of the action alternatives. The FWAC/No Action Alternative failed to meet the purpose and need for Federal action and therefore was not selected.

When compared against each other, each action alternative risk management plan was found to meet the purpose and need for Federal action and is expected to have similar amounts of reduction in risk, but varied in some key components of their overall effectiveness and completeness. Impacts, both adverse and beneficial, to the human environment are anticipated to be the same for each action alternative. It is anticipated that any adverse impacts would be avoided, minimized, or mitigated.

The single largest distinction among the final array of action alternatives was the cost. None of the action alternatives create positive economic benefits, although as discussed herein, Zoar Levee & Diversion Dam was not authorized to provide traditional economic benefits. With that understanding, when considering the efficiency of the action alternatives, the least-costly alternative was Action Alternative 6A.

Therefore, as Action Alternative 6A meets the purpose and need for Federal action in a manner that supports the expeditious and cost effective reduction of risk, it has been identified as the selected RMP/PAA.

Following implementation of the RMP/PAA and maintenance changes at the pump station and diversion channel, incremental risk would be below USACE Tolerable Risk Guidelines. These estimates assume that the leveed area does not significantly change.

It is estimated that incremental risks associated with pump failure would be lowered from 1 in 5,080 chances every year to 1 in 87,000 chances every year by the execution of maintenance packages.

It is estimated that incremental risk associated with breach of Zoar Levee would be lowered from 1 in 4,550 chances every year to 1 in 91,000 chances every year by the RMP/PAA.

As the RMP/PAA was not designed to manage risk associated with breaching of the diversion dam, no change in its estimated annual probability of failure (1 in 83,000 chances every year) and resulting consequences would occur.

Overtopping of the levee would continue to present the greatest probability (1 in 6,000 chances every year) of inundation to the leveed area. Overtopping of the levee was not addressed by the DSMS as it did not lead to breach, and therefore did not qualify as incremental risk.

This Environmental Assessment is prepared pursuant to the National Environmental Policy Act, Council on Environmental Quality Regulations (40 CFR 1500-1508), and Corps implementing regulation, ER 200-2-2. The Environmental Assessment has concluded there are no significant impacts to the human environment associated with the implementation of the proposed Project. Therefore, a Finding of No Significant Impact is anticipated and preparation of an Environmental Impact Statement is not required.

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Table of Contents

** Chapters / Sections Associated with the Integrated Environmental Assessment (EA)*

List of Figures

List of Tables

List of Appendices (Included on Disc)

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1.0 INTRODUCTION AND BACKGROUND

The U.S. Army Corps of Engineers (USACE), Huntington District, (Huntington District) and Great Lakes and Ohio River Division-Dam Safety Production Center (LRD-DSPC), with the assistance of a Risk Cadre centered in USACE, New England District (New England), and USACE, Risk Management Center (RMC) has prepared the following Final Dam Safety Modification Report (DSMR) and Environmental Assessment (EA) for the Zoar Levee & Diversion Dam. The Final DSMR/EA has been prepared in accordance with Engineering Regulation (ER) 1110-2-1156 (USACE Safety of Dams – Policy and Procedures), Section 102(C) & (D) of National Environmental Policy Act of 1969 (NEPA) and Council on Environmental Quality implementing regulations, 40CFR 1500-1508 and ER 200-2-2 (USACE Procedures for Implementing NEPA).

Zoar Levee & Diversion Dam are located upstream of Dover Dam, in Tuscarawas County, Ohio on the Tuscarawas River (see **Figure 1-1** and **Figure 1-2**). Dover Dam is a dry dam (run of river) built on the Tuscarawas River to help reduce flood risks in the Muskingum River Basin. Dover Dam is one of 16 Flood Risk Management (FRM) dams in the basin built by USACE. Zoar Levee & Diversion Dam is an appurtenant structure to Dover Dam. Zoar Levee & Diversion Dam was built in the 1930s to keep Zoar Village from having to be acquired for flowage easement to store flood waters behind Dover Dam.

USACE has developed a Dam Safety Action Classification (DSAC) system to provide consistent and systematic guidelines to address dam safety issues and deficiencies at USACE projects. DSAC ratings are informed by the incremental risk. The incremental risk is the risk (likelihood and consequences) associated with the presence of a dam or project that can be attributed to its breach prior or subsequent to overtopping, or due to component malfunction or misoperation.

Zoar Levee & Diversion Dam is a DSAC 3 Moderately Urgent for action project because the potential consequences to a unique and valued historical site from a failure of the project are unacceptable and the probability of failure of the project indicates a moderate urgency for action.

The DSMR documents the completion of a Dam Safety Modification Study (DSMS) which was designed to further define Dam Safety issues, establish a Federal interest in continuing to operate the project, and assess the risk identified for significant failure modes, or significant ways in which the project could fail. An array of reasonable alternatives, or risk management plans, were then formulated, evaluated and compared to identify a risk management plan to reduce the identified Dam Safety risks at Zoar Levee & Diversion Dam. The integrated EA documents the potential effects to the human environment that risk management alternatives may have, and how these potential effects were considered in identifying the risk management plan or the preferred action alternative (RMP/PAA).

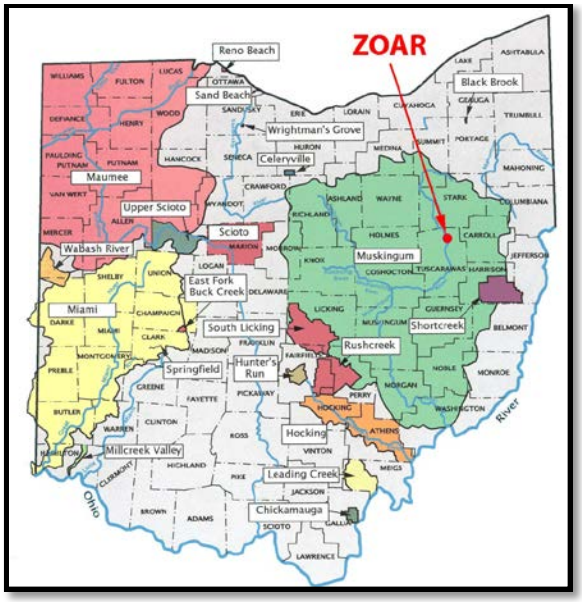

Figure 1-1 Location of Zoar Levee & Diversion Dam on the Tuscarawas River, within the Muskingum River Watershed (in green)

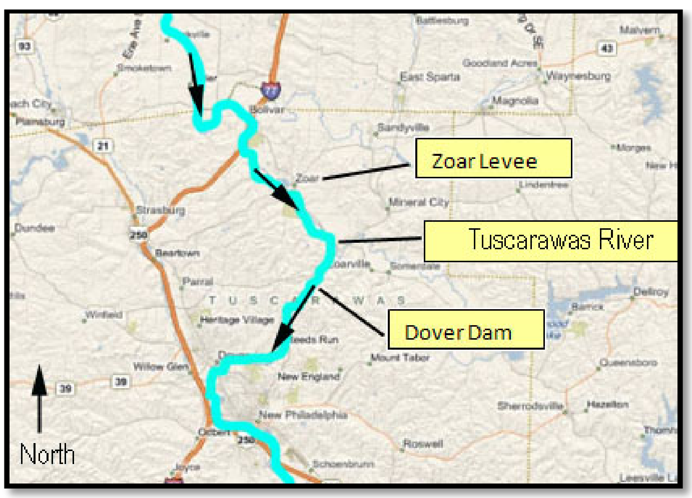

Figure 1-2 Location of Zoar Levee & Diversion Dam in relation to Dover Dam along the Tuscarawas River

1.1. Final DSMR/EA Organization

The remainder of Chapter 1 describes the purpose and need for the DSMS, provides a brief description of the authorized project purposes, and summarizes the location, description, history, current and projected use of Zoar Levee & Diversion Dam. Finally, a justification for continued Federal investment in Zoar Levee & Diversion Dam is provided.

The DSMS followed the six step framework of the civil works planning process contained in ER 1105-2-100 (Planning Guidance Notebook) as adapted for addressing Dam Safety issues in ER 1110-2-1156.

The remainder of the Final DSMR/EA is organized according to these steps and in accordance with Sub-Appendix W-2 in ER 1110-2-1156.

- **Chapter 2.0** provides information on the issues and opportunities, as well as goals, objectives and constraints of the DSMS. This chapter flushes out the purpose and need for Federal action.
- **Chapter 3.0** describes the existing and future without Federal action risk condition. This chapter also includes information on the affected environment, what the existing risks are and what risks are expected if no action is taken under the Dam Safety program. In this chapter the significant Potential Failure Modes (PFMs) requiring action are outlined. Significant PFMs are those ways the project could fail that have a probability of occurring, that when combined with the potential consequences of failure, create risks which USACE does not consider tolerable.
- **Chapter 4.0** describes how a final array of potential alternative risk management plans was identified, screened and refined to address the PFMs discussed in **Chapter 3.0**.
- **Chapter 5.0** summarizes the evaluation of the new risk condition expected for each of the final array of action alternative risk management plans against the existing and Future Without Action Condition (FWAC) risks estimated in **Chapter 3.0**. Specifically, the benefits and impacts of each alternative, including how they might impact the affected environment, are identified.
- **Chapter 6.0** summarizes the comparison of benefits and impacts of each alternative risk management plan, and identifies the selected RMP/PAA. Considerations of cost-sharing, real estate and environmental resources will also be described.
- **Chapter 7.0** provides a summary of the Type I Independent External Peer Review (IEPR) as required by ER 1165-2-214 (Civil Works Review Policy) and Section 2034 of the Water Resources Development Act (WRDA) of 2007.
- **Chapter 8.0** provides a summary conclusion of the DSMS.

1.2. *Purpose & Need

The DSMS is being conducted to obtain approval to modify Zoar Levee & Diversion Dam to address incremental risk associated with dam safety issues which would result in unacceptable consequences if the project were to fail. USACE Tolerable Risk Guidelines, defined in Chapter 5 of ER 1110-2-1156, were utilized to define what dam safety issues present unacceptable risks. For the purposes of this report, failure is defined as a sudden, rapid, uncontrolled release of impounded water.

The need for the DSMS was first identified following two successive storm events which occurred in January of 2005 (January 2005 Event) and March of 2008 (March 2008 Event). These events loaded the exterior of Zoar Levee with water being impounded on the Tuscarawas River by Dover Dam. During these two events significant seepage through foundation soils and underlying bedrock led to concern that the levee was possibly progressing toward failure. Flood-fighting was required during both events, culminating with the need for emergency action in 2008 in the form of a $1.26 M emergency seepage blanket.

In addition, the Zoar Diversion Dam has experienced unsatisfactory performance in the past. The Zoar Diversion Dam was built to help control interior flooding from Goose Run within Zoar Village. Goose Run flows through Zoar Village prior to its confluence with the Tuscarawas River. Over its life, the Zoar Diversion Dam has had several seepage issues resulting from its impoundment. Remedial actions have been taken to address these issues, but the Zoar Diversion Dam has remained dry or run-of-river since it was drained in the 1990s.

Following observations of performance during the March 2008 Event, Zoar Levee & Diversion Dam was classified as a DSAC 1 project, as progression toward failure was believed to be taking place under normal operations. The USACE DSAC ratings range from DSAC 5 - Normal, to DSAC 1 - Very High Urgency. The DSMS was initiated as a result of the DSAC 1 designation. In accordance with ER 1110-2-1156, DSAC 1 projects move directly into a DSMS, skipping an Issue Evaluation Study (IES).

As discussed above, Zoar Levee & Diversion Dam has since been re-classified as a DSAC 3 project, following a more thorough review of the project risks conducted for the DSMS (and reported in **Chapter 3.0**). In summary, this analysis indicated it would take more severe and less likely events to initiate a failure of the project, and progression toward failure was not believed to be taking place under normal operations. Further, risk estimates also indicate that life-loss and economic consequences are relatively low in comparison to other projects in the USACE dam portfolio.

However, as will be discussed in **Section 3.2**, the annual probability of a failure at Zoar Levee is still above the USACE Tolerable Risk Guidelines. When combined with the potential consequences of failure to the historical value of Zoar Village, completion of the DSMS to identify a plan to manage this risk was warranted.

As will be detailed in **Chapter 3.0**, the DSMS is focused on addressing incremental risks associated with the following:

- Water seeping through pervious soils beneath Zoar Levee (called underseepage) and exiting on the Village-Side of the levee. This issue occurs when the River-Side of the levee is loaded with water from Dover Dam's impoundment and has the potential to cause a failure or breach prior to overtopping of the levee.

- Misoperation of the diversion dam, failures of 65 year old pumps, and an undersized culvert in the diversion channel that could result in inundation due to the pump station being overwhelmed.

Therefore, the **purpose and need for Federal action at Zoar Levee & Diversion Dam is to reduce and manage incremental risks which do not meet USACE Tolerable Risk Guidelines**.

1.3. Project Authorization and Appropriate Funding Legislation

The following section provides summary information on how, why, and with what authority Zoar Levee & Diversion Dam was constructed and is maintained. For a more comprehensive discussion of the project authorization, please see **Appendix A-Volume I**.

Section 202 of National Industrial Recovery Act (P.L. 73-90, 48 Stat. 195 / Codified at 15 U.S.C. 703) (NIRA) authorized the Federal government to construct, finance, or aid in the construction or financing of any public works projects. This section granted the authority to execute the plans discussed below to construct flood control projects in the Muskingum River Basin in cooperation with the Muskingum Watershed Conservancy District (MWCD) (Jenkins 1976).

The MWCD developed a "General Plan" for flood control and the Ohio State Advisory Board requested $41,640,000 to implement the plan. In response to this request, the Public Works Administration (PWA), also established by NIRA, awarded a grant of $22,090,000 to USACE to construct the proposed plan. MWCD and USACE then cooperated in the preparation of an "Official Plan."

The 1934 "Official Plan" included 14 dams and several upstream appurtenant levees to protect critical infrastructure and some communities located upstream of these reservoirs. While none of the appurtenant levees are specifically mentioned in the Official Plan, Zoar Levee & Diversion Dam was, by default, authorized by an amendment to the Official Plan, in which it was determined to replace a planned reservoir at Massillon with one at Bolivar (Jenkins 1976) to, among other things, help facilitate constructing Zoar Levee.

Construction began in 1935 with the award of construction contracts. Construction of Dover Dam was completed on November 29, 1937 at a cost of $7,755,300 which included Zoar Levee & Diversion Dam. On July 1, 1938, the 14 dams and their appurtenant structures were turned over to the MWCD for operation and maintenance in accordance with the Official Plan.

In accordance to the 1934 agreement, the MWCD originally contributed $12,500,000 of the total cost of $34,590,000 for all dams in the Official Plan (36 percent). The Rivers and Harbors Act of 1938 (52 Stat. 1217) directed the Secretary of War to reimburse MWCD $4,500,000 reducing their cost share to $8,000,000 or 23 percent of the total project cost.

Following Passage of § 4 of the Flood Control Act of 1939 (53 Stat. 1414) (FCA 1939), MWCD transferred all operation and maintenance responsibility to USACE.

> *The flood-control plan for the Ohio River Basin authorized in section 4 of the Act of June 28, 1938…..shall include the Muskingum River valley dams and reservoirs as set forth in the Official Plan of the Muskingum Watershed Conservancy District and the provisions of section 2 of said Act (for acquiring by the United States of lands, easements, and rights-of-way for flood-control projects) shall apply thereto…..* (Flood Control Act of 1939)

The FCA of 1939, and by default the Official Plan, are the authority the Federal government uses to operate and maintain the Muskingum projects, including Zoar Levee & Diversion Dam.

Without Zoar Levee & Diversion Dam, all portions of Zoar Village located at or below El. 916 feet[1] would have been permanently evacuated at the time of Dover Dam's construction (see **Figure 1-3** below). A specific formulation document for Zoar Levee & Diversion Dam has not been identified. However, documentation summarized below concerning the decision to construct the levee verses remove the town from Dover Dam's flowage easement indicates public concern caused MWCD and USACE to consider the historical significance of the community when making this decision.

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[1] All elevations referenced in this report are in feet above mean sea level, NGVD 29 unless otherwise noted.

Figure 1-3 Aerial photograph showing portion of Zoar Village below El. 916 feet (highlighted in blue)

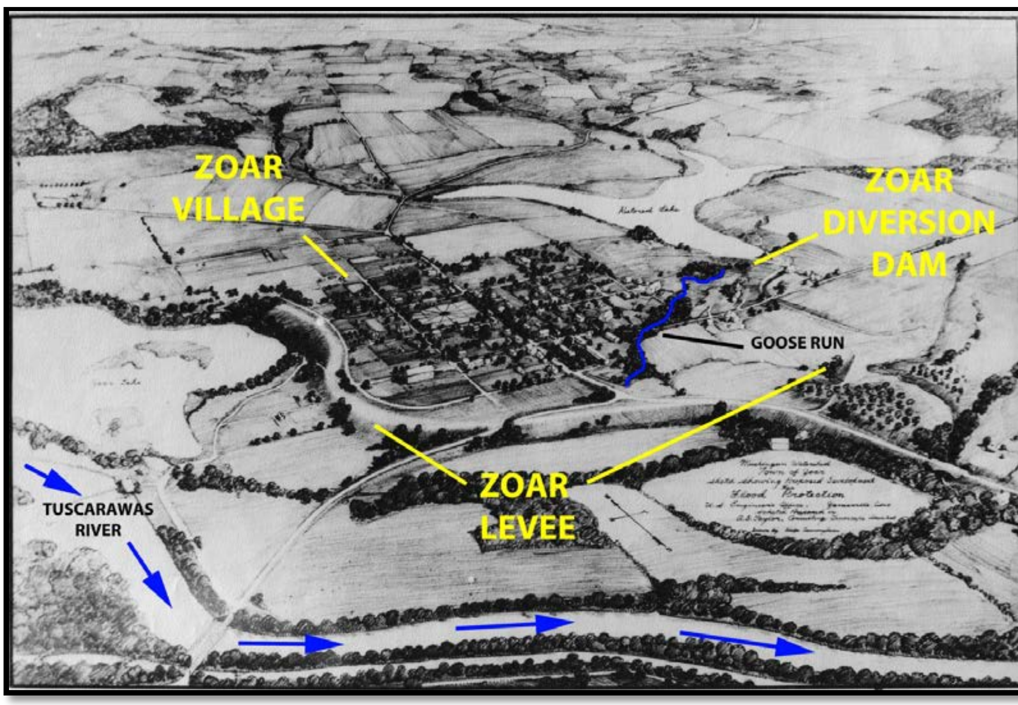

Figure 1-4 Artist rendering (1934) of Zoar Levee & Diversion Dam surrounding Zoar Village (location references added)

A review of period records indicates that after receiving letters of protest from Zoar residents, concerned historians, the Ohio State Archaeological and Historical Society (OSAHS), and Ohio's U.S. Senator Robert J. Buckley, a decision was made by USACE to design a levee rather than purchase and evacuate that portion of the Zoar Village which would have been within Dover Dam's flowage easement (Zoar Village 1935).

Post-construction documents confirm Zoar Village's historical significance and tourism potential were the key factors in deciding to construct Zoar Levee & Diversion Dam. For example, a 1950 memorandum concerning raising the crest of Zoar Levee stated:

> "*At the time Dover Dam was being planned, consideration was given to evacuating the population of 200 persons. However, since the village is of considerable historical importance and since two state-owned museums are located there, it was decided to protect the site by constructing earth levees rather than to evacuate the population.*" (USACE 1950)

This makes Zoar Levee & Diversion Dam a unique project in LRD, in that it was not constructed to accrue typical or traditional flood risk management benefits (e.g. reduce damages to large population center, critical infrastructure or industrial manufacturing). According to the USACE Technical Center of Expertise (TCX) for the Preservation of Historic Buildings, Zoar Levee & Diversion Dam is one of the earliest, if not the earliest, example of a flood risk management project by USACE designed for the sole protection of a historic community (McCroskey Personal Communication 2013). As discussed in **Section 3.4.2**, Zoar Village today has evolved into a significant social, recreational and cultural/historical resource.

1.4. Location and Description

Zoar Levee & Diversion Dam is located in Lawrence Township of Tuscarawas County, Ohio along the floodplain of the Tuscarawas River, which is a tributary of the Muskingum River. The site is most easily accessed by traveling State Route 212 east from Exit 93 off I-77 (Bolivar Exit). Zoar Levee & Diversion Dam is a component of Dover Dam and is located approximately four miles upstream of Dover Dam on the Tuscarawas River. Dover Dam is a dry dam and retains impoundments only during high water events to attenuate downstream flooding in coordination with other Muskingum Basin projects. Zoar Levee & Diversion Dam is also located approximately four miles downstream of Bolivar Dam, another dry dam (see **Figure 1-5** below). Dover Dam's flowage easement and resulting impoundments can and do back up to the toe of Bolivar Dam.

1.4.1. Regional Geology

The project is also approximately 4 miles downstream of the southern extent of the Wisconsin-age glacial advancement. Prior to glacial recession, one or more lakes were impounded by glaciers which laid down lacustrine deposits at the location of Zoar Levee & Diversion Dam. These lakes impounded a stream, known as Zoar Creek, that originally flowed north-northwest near the location of Zoar Levee & Diversion Dam. The glacial lakes were finally emptied when they overtopped a low area near the location of Dover Dam, cutting a new river valley which flowed south-southwest near the location of Zoar Levee & Diversion Dam. As the glacier retreated, outwash from melt waters deposited and reworked previous deposits. Following glacial retreat, the Tuscarawas River has meandered through the valley, reworking outwash and lacustrine deposits, as well as depositing more fine grained alluvium on top of those previous deposits.

For the most part, this geologic history has resulted in nearly 130 feet of deposits overlaying the bedrock at Zoar Levee. At the Rock Knoll Reach (described in **Section 1.4.2.2**), the bedrock is located within 5-15 feet of the ground surface. The Zoar Diversion Dam (also described in **Section 1.4.3**) is located on and abutted by the same bedrock.

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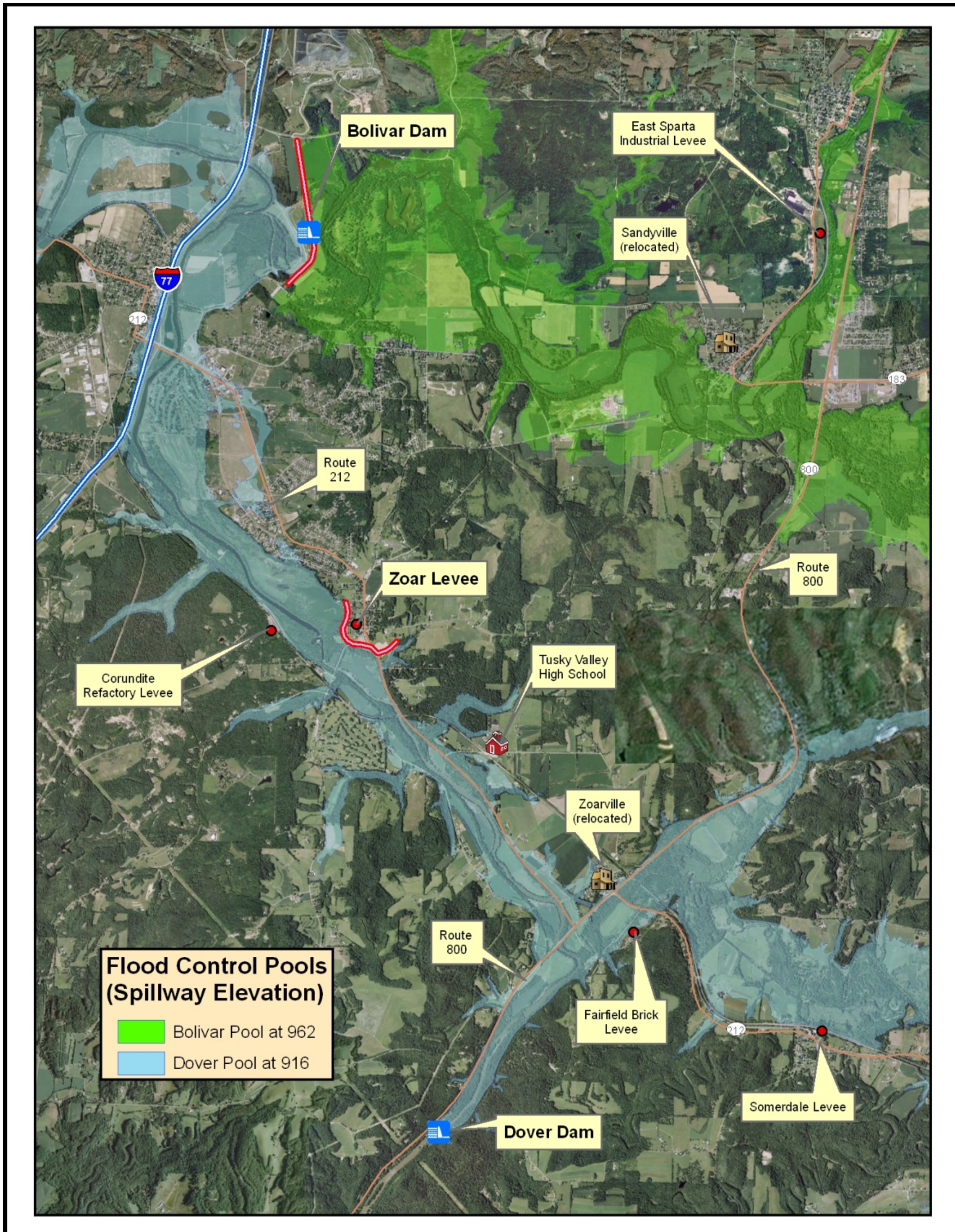

Figure 1-5 Location of Zoar Levee in relation to Dover and Bolivar Dams and their flowage easements charted in blue and green, respectively.

1.4.2. Zoar Levee

Zoar Levee (see **Figure 1-6** below) is a rolled-earth filled embankment with an impervious core, sandy inner shells, impervious outer shells, and a crest length of 3,893 feet. Zoar Levee protects Zoar Village when Dover Dam is retaining an impoundment. As such, the original crest elevation of Zoar Levee was designed to correspond to the spillway elevation of Dover Dam at El. 916 feet, with an additional three feet of freeboard for a resulting crest elevation of 919 feet. Following work in 1951 the crest elevation was raised to El. 928.5 feet. With the exception of leveed areas, the Federal government maintains flowage easement upstream of Dover Dam to El. 916 feet.

Figure 1-6 Aerial photograph charting major project features of Zoar Levee & Diversion Dam.

1.4.2.1. Ball Field Reach

For discussion purposes, USACE generally breaks the levee into two reaches (see **Figure 1-6** above). The Ball Field Reach of the levee is the portion located west of Route 212 and is called such due to the presence of a Little League ball field. The Ball Field Reach is built upon a thin intermittent alluvial blanket over a mix of glacial outwash, alluvium, and lacustrine deposits approximately 130 feet thick in the deepest valley section.

Deep pervious foundation deposits have allowed for a condition where water seeps or travels underneath the levee (called underseepage) regularly when the River-Side of the levee is loaded with water from Dover Dam's impoundment, sometimes exiting on the Village-Side of the levee. The alluvial blanket, called a confining layer, when thick enough, can resist the resulting water pressures. However, the alluvial blanket is somewhat intermittent and does not have a consistent thickness. In addition, there is concern and evidence this alluvial blanket has heaved and cracked in the past, allowing for seepage to exit in a more concentrated manner. While the geomorphic environment is challenging to characterize given its complex depositional origin (see **Section 1.4.2**), there is concern uniform sands exist underneath the levee which could be eroded out at seepage exit points during an elevated Dover Dam impoundment. If this erosion were to occur at a location with certain geologic conditions and with enough water against the levee for the sufficient amount of time, the levee could fail or breach. As will be discussed in **Section 3.2.1**, the probabilities of this occurring are above USACE tolerable limits (1 in 10,000 annual chance).

1.4.2.2. Rock Knoll Reach

The Rock Knoll Reach is the portion of the levee located east of Route 212 and is generally characterized by colluvial/residual deposits of variable thickness, situated on a localized bedrock high point; this area was "high ground" prior to the raising of the levee in 1951. The Rock Knoll consists of jointed and fractured sandstone and limestone, interbedded with shale.

Open and solutioned fractures within the limestone allow water to seep or travel through the rock when the River-Side of the levee is loaded with water from Dover Dam's impoundment. This seepage then exits on the Village-Side of the levee. This condition has caused large concentrated seepage exit points, sometimes referred to as boils. The size and amount of water flowing out of the boils caused significant concern during the March 2008 Event, leading to the installation of an emergency seepage blanket. However, as detailed in **Appendix A – Volume I**, following installation of the emergency blanket and a more thorough analysis of the risks associated with this seepage, it was determined this condition does not pose probabilities of failure above USACE tolerable limits.

1.4.3. Zoar Diversion Dam

Zoar Diversion Dam (see **Figure 1-6** above) is located on Goose Run, approximately 1,000 feet upstream of Zoar Levee and was built to control interior drainage as a temporary retention structure for runoff from the Goose Run watershed. The Diversion Dam is a rolled earth-filled embankment with an impervious core. It is approximately 500 feet long and 35 feet high with a crest width of 16 feet and a design crest elevation of 932 feet. A thin layer of alluvium was left underneath the shells of the dam, but the core sits directly on bedrock. The Diversion Dam foundation and abutments contain similar rock conditions described for the Rock Knoll Reach of the levee.

This geology has caused concern that seepage through fractured rock could pose significant risks to the public. However, as detailed in **Appendix A – Volume I**, following installation of the various treatments and remediation's over time and a more thorough analysis of the risks associated with this seepage, it was determined that this condition does not pose probabilities of failure above USACE tolerable limits.

The Zoar Diversion Dam is designed with the ability to temporarily retain interior drainage up to El. 916 feet. Above this elevation, water is diverted through an auxiliary spillway called the Zoar Diversion Channel (see **Figure 1-5** above), which empties into Dover Dam's flowage easement outside the levee. This diversion channel can also allow water retained by Dover Dam to back onto the Diversion Dam in the event an impoundment at Dover exceeds El. 916 feet.

Downstream of the Diversion Dam, Goose Run flows through Zoar Village before it empties into a ponding area on the Rock Knoll Reach of the levee. Under normal conditions, Goose Run flows underneath Zoar Levee through a 3-x-3 foot culvert. This culvert can be closed by a single sluice gate located on the River-Side embankment of Zoar Levee. See **Figure 1-6** above for a detailed layout of the project.

When Zoar Levee's River-Side embankment is loaded by Dover Dam's impoundment, the outflow culvert underneath the levee must be closed. The Zoar Pump Station (**Figure 1-6**) was added in 1950 at the location Goose Run exits Zoar Levee to pump water released from Zoar Diversion Dam over the levee. The pump station also accepts water from Zoar Village's interior stormwater systems and the seepage collection measures put in place along the interior toe of the Ball Field and Rock Knoll Reaches of the levee. The Zoar Pump Station consists of three motor-driven mixed flow pumps (with 125 and 150 horsepower motors) that can pump up to a total of 45,000 gallons per minute of water to the exterior of Zoar Levee. Pumped water exits the exterior slope of Zoar Levee via conduits which follow the levee's crest geometry.

As will be discussed in **Section 3.2.2**, concerns that misoperation of the dam, component failures associated with the pump station, and an undersized culvert in the diversion channel, result in probabilities of inundation which are above USACE tolerable limits (1 in 10,000 annual chance).

1.4.4. Seepage Management Features

Several seepage management features have been added to the project over time (see **Figure 1-7** and **Figure 1-8**). These include 14 operational relief wells, nine of which are 65 years old and do not meet current design standards and have not been properly maintained. Overall, the relief well system has failed to provide much benefit in reducing performance related issues. See **Appendix A – Volume I** for a more thorough description of all the features of Zoar Levee & Diversion Dam.

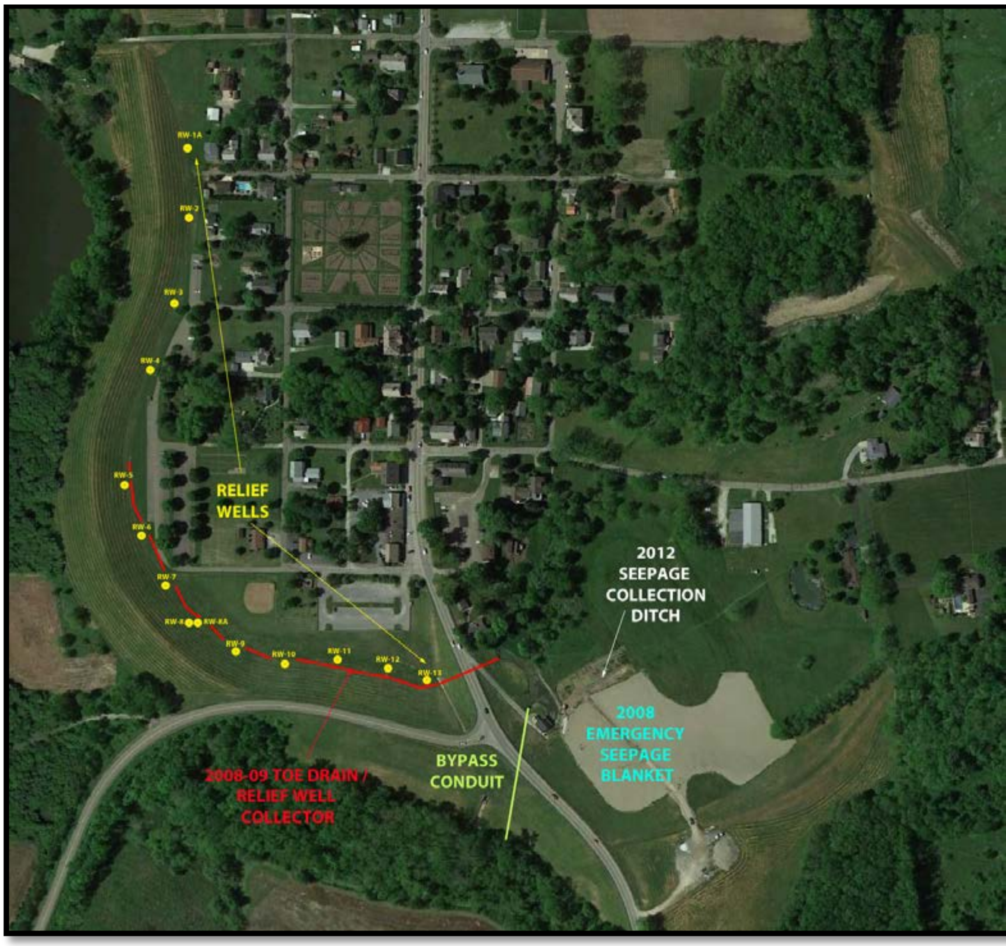

Figure 1-7 Seepage management features at Zoar Levee

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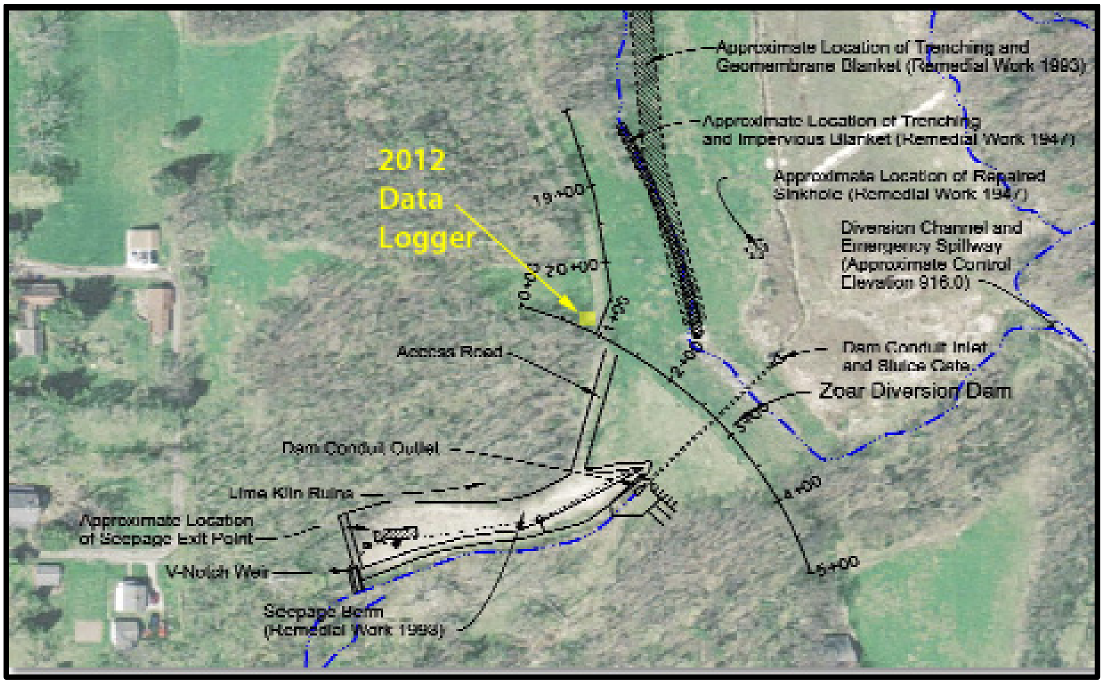

Figure 1-8 Seepage management features at Zoar Diversion Dam.

1.5. Past Performance

Summaries of past performance and investments made at Zoar Levee & Diversion Dam are provided in **Table 1-1**, **Table 1-2**, and **Table 1-3**. The two most pertinent events are described below.

<u>January 2005 Event</u>: In 2005, a Dover Dam impoundment occurred loading Zoar Levee for a month and peaking at El. 907.4 feet (see **Figure 1-9** below). This event spanned the entire Muskingum Basin, and was responsible for pools of record at 11 projects. For Dover Dam, this event exceeded the previous record (1969) by 2.4 feet. At Zoar Levee, numerous small “pin” boils were noted over a large area on the Ball Field Reach and more concentrated seepage was found on the Rock Knoll Reach of the levee. Huntington District installed rings of sand bags around the seeps and attempted to place a small granular filter berm to reduce the movement of soil particles. Saturated ground conditions did not allow for the installation of the filter blanket. The reservoir level soon dropped and eliminated the potential need for further action. A 2006 Screening Portfolio Risk Assessment (SPRA) of Zoar Levee & Diversion Dam led to a DSAC 2 rating, citing “extensive seepage and small boils” and rating both the levee and diversion dam as “Probably Inadequate” for seepage and piping under “Normal” loading conditions.

<u>March 2008 Event</u>: In 2008, another significant Dover Dam impoundment occurred, loading Zoar Levee for a month and peaking 3 feet below the 2005 impoundment, at El. 904.6 feet (**Figure 1-9**). This was a more localized event than in 2005, but did load other nearby projects. At Zoar Levee’s Rock Knoll Reach, large concentrated seepage, or boils, appeared at several locations on the Village-Side of the levee.

Early, during the March 2008 Event, sand bags were placed around concentrated seep exits on the Rock Knoll Reach for approximately two and a half weeks (see **Figure 1-9** below). During this time, the number and size of concentrated seep exits and the total quantity of seepage across the area increased significantly. There was a concern that this water flow may have been eroding not only the soils in the immediate vicinity, but also those within the foundation of the levee. Without the ability to interpret whether the seepage was flowing solely through bedrock or dangerously along the bedrock/soil contact, the changing locations and increasing seepage quantities were considered as just cause to declare an emergency. During the emergency situation, it was decided to construct a $1.26 M emergency seepage blanket using 37,000 tons of granular material (Carter et al 2008).

At the same time, widespread small boils and pervasive area seepage were again observed on the Ball Field Reach of the levee. The largest boil observed was six inches in diameter. Flooding-fighting actions taken included increased surveillance and instrumentation monitoring, lowering of well risers, and a preliminary design of a emergency berm, which was ultimately not required due to the impoundment receding. The March 2008 Event resulted in Zoar Levee & Diversion Dam being reclassified as a DSAC 1 project, as progression toward failure was believed to be occurring.

Following this event, USACE could not provide a positive Levee System Evaluation (LSE) with a reasonable assurance that Zoar Levee could withstand a flood event having a one percent chance of being equaled or exceeded in any given year, referred to as the base flood event. As a result, Zoar Levee was de-accredited and portions of Zoar Village were included in the regulatory floodplain.

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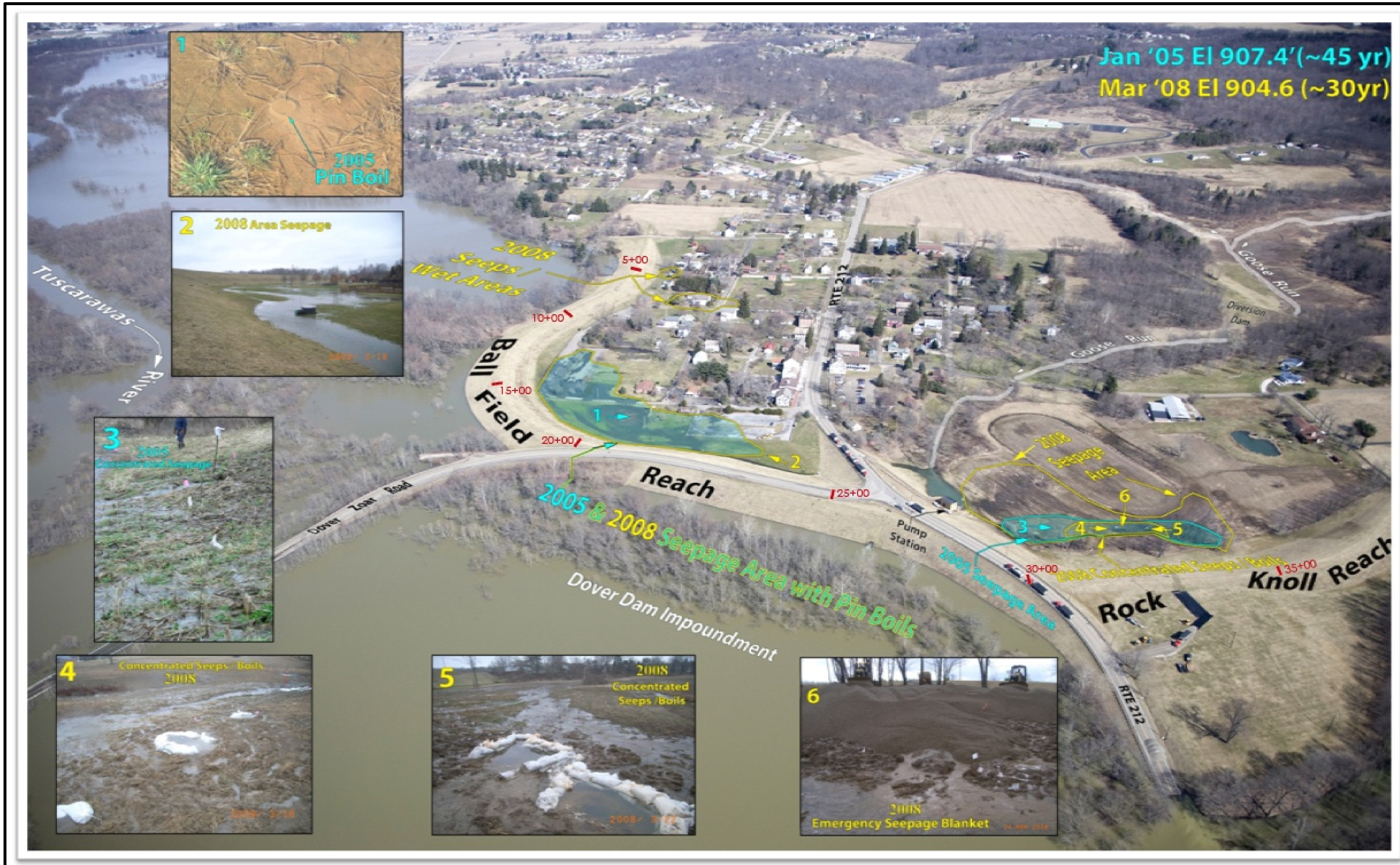

Figure 1-9 Aerial photograph showing performance issues observed during 2005 & 2008 events

Table 1-1 History of Zoar Levee

Date	Activities / Events	Cost
1935-1939 Construction	Zoar Levee constructed to crest El. 919 ft	$121 k (+ real estate & relocations)
1947 Event	Zoar Levee loaded to El. 902.7 ft; seepage and interior run-off inundated Zoar Village to El. 895.2 - 895.4 ft	NA
1948 Seepage Remediation	Fourteen 40-ft deep relief wells, spaced ~ 125 ft apart, added to Village-Side of Ball Field Reach. 13 piezometers installed between relief wells	$14 k
1950 Upgrade	Zoar Pump Station added	UNK
1950-1951 Addition	Zoar Levee crest raised to El. 928.5 ft	$345 k
1952 Event	Zoar Levee loaded to El. 897.7 ft; seepage and basement flooding observed;	NA
1959 Event	Zoar Levee loaded to El. 901.6 ft; seepage and basement flooding observed	NA
1969 Event	Zoar Levee loaded to El. 905.0 ft; seepage and basement flooding observed	NA
1975-2011 Slide Repairs	Shallow slides noted and re-dressed in three locations (not performance-associated)	UNK
1991 Event	Zoar Levee loaded to El. 895.7 ft; basement flooding and storm sewer overflow observed	NA
1994-1995 Improvements	Relief wells 11-13 replaced; five piezometers added	UNK
January 2005 Event	Zoar Levee loaded to El. 907.4 ft; widespread seepage and basement flooding observed. Resulted in DSAC 2 assignment	NA
March 2008 Event	Zoar Levee loaded to El. 904.6 ft; widespread seepage and basement flooding observed; emergency declared and action taken to install emergency seepage blanket. Resulted in DSAC 1 assignment	NA
2008 Emergency Blanket	37,000 ton granular emergency seepage blanket installed at Rock Knoll	$1.26 Million
2008-2011 IRRMs	See Table 1-3	See Table 1-3
March 2011 Event	Zoar Levee loaded to El. 900.6 ft; seepage and basement flooding observed	NA
August 2014 Event	4.25” rainfall, water ponded on Village-Side to El. 892’	NA
NA = Not Applicable / UNK = Unknown		

Table 1-2 History of Zoar Diversion Dam

Date	Activity / Event	Cost
1935-1939 Construction	Zoar Diversion Dam constructed	Included in Levee Costs
1947 Event	Right abutment seepage observed; reservoir sinkhole observed	NA
1947 Seepage Remediation	Impoundment drained; filled sinkhole; exposed and grouted bedrock on upstream abutment	UNK
1970 Seepage Observations	Clear seepage observed on downstream toe and around outlet conduit	NA
1976 Seepage Observations	Clear seepage observed on downstream toe and around outlet conduit	NA
1978 Seepage Remediation	Toe drain installed, lowered outlet channel to provide positive drainage, filled and repaired depressions on downstream slope, regraded upstream slope and dressed with stone for wave action protection	$88k
1989-91 Seepage Observations	500 gallons per minute seepage reported 300 ft downstream of conduit outlet on right-descending bank, caused lake level to drop approximately 10 ft	NA
1992 Impoundment Draining	Impoundment behind Zoar Diversion Dam permanently drained	UNK
1993 Seepage Remediation	Installed upstream impervious geomembrane; installed downstream seepage berm with collection system	$328k
2008-2012 IRRMs	See **Table 1.3**	See **Table 1.3**
August 2014 Event	4.25” rainfall, water impounded behind Diversion Dam to El. 913.	NA
NA = Not Applicable / UNK = Unknown		

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Table 1-3 Summary of Implemented IRRMs at Zoar Levee & Diversion Dam

IRRM	Benefits	Challenges	Costs
2008 Communication Plan	Improve Communication	Requires Regular Updates	NA
Surveillance Plans for Levee & Diversion Dam	Sets Strategy for Monitoring	Guide Only, Resources and Access May Be Limited	NA
Crest Profiles for Levee & Diversion Dam	Baseline Data, Defines Overtopping Locations	Does Not Reduce Any Immediate Risk	$12k
Store Sand Bags at Pump Station (and purchase sandbagger)	Easy Access During Flood Fight	Requires Adequate Sand & People; Bags Can Deteriorate	$4k
2008 Emergency Blanket	Prevented Potential Failure; Aid in Controlling Seepage in Future Events	Designed to be Temporary; Does Not Meet Filter Design Criteria; Obscures Surveillance / Not Designed for Impoundments over El. 909 feet	$1.26 M
Stockpile Granular Material / ID Vendors	Easy Access During Flood Fight	Limited Volume / Update Vendor List; Flood Events Limit Access to Site	Included in 2008 Emergency Blanket Costs
Levee & Diversion Dam Conduit and Pipe Inspections	Better define the risk these features have in association with PFMs	Does Not Reduce Any Immediate Risk	$12.6k
Levee Toe Drain and Relief Well Collector System	Intercepts, Collects, Discharges Seepage from Ball Field Reach to Pump Station; Aid in Controlling Seepage in Future Events.	Limited Effectiveness; Requires Maintenance; Not Designed for Impoundments over El. 909 feet.	$1.8 M

IRRM	Benefits	Challenges	Costs
Assessment & Rehabilitation of Existing Relief Wells	Increase Effectiveness of Relief Wells; Reducing Risk of Seepage Issues from Relic Wells	Requires Maintenance: System is Minimally Effective	$655k
Upgraded Zoar Pump Station with 3rd Pump	Additional Pumping Capacity to Reduce Risk of Interior Flooding and Increase Success of Inspections during Events	Potential for Increase Inflow in Future	$777k
Upgraded Zoar Pump Station with New Emergency Generator	Operate All Three Pumps with Loss of Commercial Power	Diesel Fuel Must Be Replenished Frequently to Avoid Algae Build-up	Included in cost of 3rd pump
Automated Pump Station	Free Up Personnel for Other Emergency Activities	Reduce Perceived Need to Inspect Pumps-	Included in cost of 3rd pump
Zoar Pump Station Phone Gage	Alerts Staff if Pumps Are Not Working	Relies on Working Telecom Infrastructure	NA
Addressed Shallow Embankment Slides	Reduces Potential for Future Movement of Embankment Material	None	$6k
Zoar Levee Seepage Collector Ditch and Weir	Better Monitoring During an Event	Weir can Become Submerged	$258k
Install Pool Gage and Alerting Capability at Diversion Dam	Alert of Involuntary Impoundments	Relies on Working Telecom Infrastructure	$38k
NA = Not Applicable / UNK = Unknown			

1.6. Current Use of the Project

Zoar Levee & Diversion Dam has no authorized purposes beyond flood risk management, such as recreation or water supply. The Zoar Diversion Dam once impounded a recreational reservoir. This reservoir was permanently drained in 1992 following performance issues summarized in **Appendix A – Volume I**. As a permanent impoundment was never authorized, a permanent reservoir cannot be established without further authorization.

The project is usually dry, or not holding flood waters back from either the Tuscarawas River or Goose Run. Therefore, it is not manned by permanent project staff. Instead, staff assigned to Dover Dam is also assigned operations and maintenance duty at Zoar Levee & Diversion Dam.

As discussed above, Zoar Levee is designed to reduce flooding up to a Dover Dam impoundment at El. 925.5 feet with three feet of freeboard. Analysis indicates an impoundment at this elevation would have a 1 in 6,000 chance of occurring each year. At this point, Dover Dam's spillway crest (El. 916 feet) is overtopped and it is no longer controlling outflows. **Figure 1-10** below provides a graphic representation of the relationship between Dover Dam, Zoar Levee and Zoar Diversion Dam.

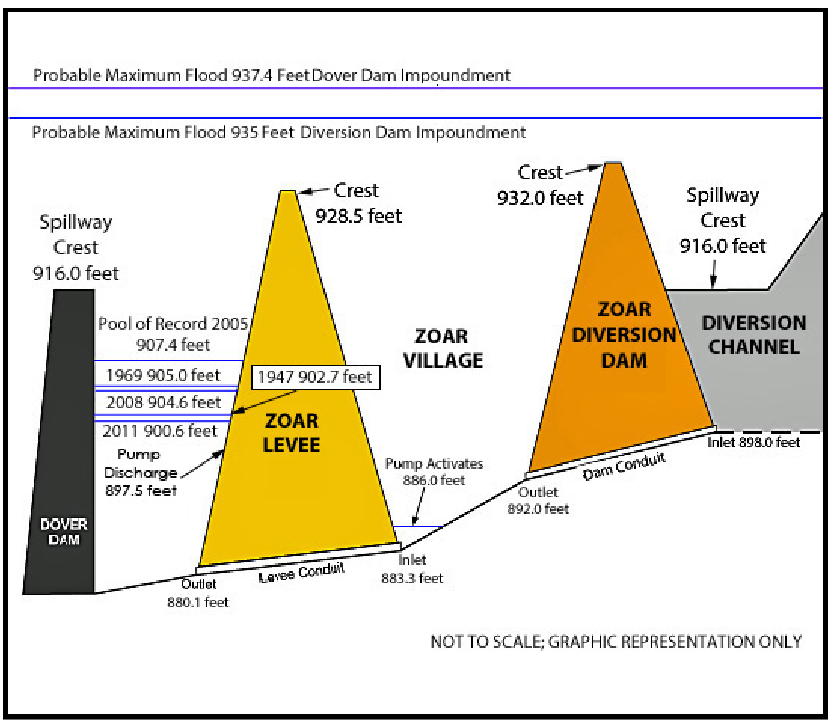

Figure 1-10 Graphic representation of key elevations at Dover Dam and Zoar Levee & Diversion Dam, the five highest Dover Dam impoundments, and the Probable Maximum Floods for Dover Dam and Zoar Diversion Dam.

1.7. Future Use of the Project

It is not anticipated that the outcome of the DSMS would impact authorized project purposes and assuming the project does not breach or otherwise fail, it is anticipated it will continue to provide authorized purposes in a manner similar to historical performance, provided climate conditions and the leveed area remain comparable to the current condition.

Potential changes in precipitation, river discharges and temperatures associated with climate change that could affect future use of the project during the period of analysis can be derived from the ongoing Ohio River Basin Climate Change Pilot Study. This study is a collaborative effort between USACE, the National Oceanic and Atmospheric Administration (NOAA), U.S. Environmental Protection Agency (USEPA), The Nature Conservancy (TNC), United States Geological Survey (USGS), Battelle Memorial Institute, and noted academic experts in climate change modeling, system impacts and adaptation strategies (Marshall University, University of Cincinnati, and University of New Hampshire). While in draft form, this study indicates that during the period of analysis (2014-2064) the largest forecast changes for river discharge in the Muskingum Basin would be 15 percent above the base year's flow (1952-2001). This large increase would likely occur during the last 10-15 years of the period of analysis. Annual mean temperatures during the period of analysis are forecasted to rise from 52.6^{F} in 2011 to 56.5^{F} in 2070 pointing towards fewer precipitation events occurring as snow versus rainfall. With this in mind, it is possible that slight increases in precipitation may occur during the later part of the period.

It is intended that future operations of the project will be conducted according to the Water Control Manual (WCM) for Dover Dam and standard operational procedures utilized by Dover Dam project staff at Zoar Levee & Diversion Dam. As will be discussed in **Section 3.2.2**, standard procedures for operating the Diversion Dam have been amended to reduce the potential for interior flooding to inundate the pump station. This operational change did not require a deviation to the WCM for Dover Dam.

A more thorough discussion of the FWAC risk is provided in **Section 3.0**.

1.8. Justification for Continued Federal Investment

Zoar Levee & Diversion Dam provides authorized flood risk management to a small population (<200 people) and associated economic development, as well as a regionally utilized heritage tourist asset and a nationally valued historical resource.

As previously discussed, Zoar Levee & Diversion Dam was not formulated to achieve traditional benefits by reducing or eliminating flood damages from natural flooding, nor was it designed to protect a large population center or major industry. If the levee had not been constructed all portions of the built environment within Zoar Village at and below El. 916 feet would have been purchased and evacuated for flowage required to impound waters behind Dover Dam.

As will be discussed in **Section 3.4.2**, and detailed in **Appendix A – Volume II**, the area protected by Zoar Levee & Diversion Dam has become the heart of a nationally significant historical site with unparalleled historical integrity which is symbiotically supported by an active and thriving resident community, as well as internal and external private and public interests (see also **Appendix D – Addendums 1 & 3**).

Put another way, the project has achieved the benefits it sought when built. Significant societal concerns about the value of Zoar Village are further detailed in **Section 3.4.2**. Given the substantial benefits resulting from the operation of the project and protection of human life and property coupled with the investment already made toward construction of Interim Risk Reduction Measures (IRRMs), continued Federal investment to address the remaining dam safety issues is warranted. No changes to the authorized project purposes appear warranted at this time.

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2.0 DAM SAFETY ISSUES AND OPPORTUNTIES

The following chapter defines the problems which exist due to dam safety issues identified at Zoar Levee & Diversion Dam. Specific risk estimates and PFMs are summarized in **Chapter 3.0**. This chapter is focused on defining the overall problem and opportunity statements, followed by a discussion of objectives and constraints.

2.1. Dam Safety Issue Statements

The first step when conducting a study is to identify the issues which need to be addressed by the study. For a DSMS, the issues must be framed in terms of Dam Safety program objectives concerning incremental risk and USACE Tolerable Risk Guidelines. Within this framework, the following summarizes the issues which needed to be addressed by the DSMS.

- Based upon past performance, Zoar Levee & Diversion Dam has the potential to present incremental risks that are above USACE Tolerable Risk Guidelines.

- Based upon past performance, Zoar Levee's ability to withstand a base flood event was uncertain. As a result FEMA no longer accredits the levee for the purposes of the National Flood Insurance Program (NFIP).

- The potential for significant incremental risks and de-accreditation of the levee has led to societal concerns about the potential consequences to a valued heritage asset and historic property. It has also frozen the continued viability of Zoar Village.

- Until the inundation risks are better understood and/or addressed, future emergency flood-fighting costs could be incurred; including but not limited to constraining USACE's ability to fully operate Dover Dam for its flood risk management purposes without consideration to upstream impacts.

2.2. Risk Reduction Opportunity Statements

The next step is to define the opportunities which exist within the framework of USACE dam safety program and Tolerable Risk Guidelines. The following opportunities were identified:

- Better define, estimate, and communicate the inundation risks Zoar Levee & Diversion Dam present to the public now and in the future;

- Better understand the ability of Zoar Levee to withstand the base flood event;

- Reduce or eliminate the probability of adverse consequences and resulting societal concerns from a failure of Zoar Levee & Diversion Dam; and

- Reduce or eliminate the need for emergency flood-fighting costs associated with poor performance or a failure of Zoar Levee & Diversion Dam.

2.3. Objectives and Constraints

As the dam safety issues and risk reduction opportunities are considered, there are also objectives and constraints which guide the DSMS in the development of the alternative risk management plan.

The overall objective of the DSMS is to identify and recommend a risk management plan which supports the expeditious and cost effective reduction of risk within the USACE portfolio of dams. More specifically, the intent of a DSMS is to identify risk management plans that addresses those PFMs, or ways the project could potentially fail, that drive the incremental risks above USACE Tolerable Risk Guidelines. Specific objectives are as follows:

- Reduce incremental risk to a level which satisfies USACE Tolerable Risk Guidelines;

- Comply with all applicable laws, regulations and consider all applicable guidelines; and

- At the request of Zoar Village, and on their behalf, use the DSMS as an LSE in accordance with 44 CFR 65.10(e) to determine if there is a reasonable assurance Zoar Levee can withstand the base flood event.

The following are also constraints which needed to be considered during the DSMS:

- Do not transfer or create risk which does harm to the public;

- Focus risk management alternative formulation to address incremental risks which do not comply with USACE Tolerable Risk Guidelines; and

- Avoid, minimize, or mitigate for impacts to the human environment; including but not limited to the social, recreational cultural/historical, environmental, and economic resources.

The next step is to estimate what the risk condition is today and could be over the next 50 years to better inform how best to manage this condition to meet dam safety issues, opportunities, and objectives, while avoiding constraints.

3.0 EXISTING AND FUTURE WITHOUT FEDERAL ACTION CONDITION RISK

The existing condition risk and future without Federal action condition (FWAC/No Action) risk provide the basis from which alternatives are formulated and benefits/impacts are assessed. The existing condition risk is defined as the risk which currently exists at the project. The FWAC/No Action risk is defined as risk which would exist over the next 50 years should the Federal government not take action. For the purposes of the DSMS, the period of analysis for the FWAC/No Action spans between 2014 and 2064. This analysis helped meet two dam safety opportunities:

- Better define, estimate, and communicate the inundation risks Zoar Levee & Diversion Dam present to the public now and in the future; and

- Better understand the ability of Zoar Levee to withstand the base flood event.

The existing condition risk was estimated and then analyses were undertaken to determine if or how those risks might change in the FWAC/No Action scenario. The existing and FWAC/No Action risks are fully documented in **Appendix A – Volumes I and II.** As the consequences are not suspected to change appreciably between the existing and FWAC/No Action conditions, a discussion of what consequences would occur from a resulting inundation is provided in **Section 3.4**.

3.1. Investigations & Studies Supporting the Existing & FWAC/No Action Risk Estimates

Geotechnical, hydrologic, community impacts, historic property, hazardous materials, environmental and economic investigations and studies were completed in order to characterize the existing and FWAC/No Action risks and the affected environment.

3.1.1. Geotechnical Investigations and Studies

Seven subsurface investigations were performed between 2007 and 2014. These included extensive soil sampling and rock coring with pressure tests, down-hole camera, and piezometer installations, as well as several shallow investigations performed with hand equipment targeting specific gaps in data identified during the DSMS. Additional detail on all the geotechnical investigations which have occurred at the project can be found in **Appendix A – Volume I** and **Appendix I**.

Data from these and previous investigations, in combination with a study of the regional and local geomorphology, were used to characterize the site. Studies were also conducted to evaluate and understand the piezometer and relief well performance throughout the project history. A comprehensive site plan, geologic profiles, geologic cross sections with graphical piezometric data, and multiple plots of piezometric and relief well flow data were developed and used during the existing condition and FWAC/ No Action risk estimation. The plots and site characterization drawings can be found in **Appendix A – Volume I**.

This information was also utilized in a seepage analysis of the Ball Field Reach which included finite element models in order to better understand the seepage flow and pressure conditions during high pool events. The gradients and derived factors of safety helped to inform the existing condition risk estimates. However, it was recognized that at higher pool levels, uncertainty existed in the results due to minimal piezometric data and the fact that the levee had only been loaded approximately halfway to its crest. Also some inputs, such as the degree of anisotropy and entrance and exit conditions were difficult to estimate, although calibration with past loadings was useful. The assumptions, methods, and results of this analysis can be found in **Appendix A – Volume I**.

A slope stability analysis was also conducted for the levee in order to determine if slope instability contributes significant risk to the levee. In order to address uncertainty and better characterize the chances of a slope failure, a probabilistic analysis was performed in addition to a deterministic analysis. The results led to the conclusion that the associated PFMs were not significant risk drivers. This analysis is further discussed in **Appendix I**.

3.1.2. Hydrologic Studies

Multiple hydrologic analyses have been performed from the inundation created by Dover Dam impoundments. The most recent analysis was part of development of the existing risk condition and included the development of a hydrologic loading curve for Zoar Levee resulting from Dover Dam impoundments. A hydrologic loading curve was also developed for Zoar Diversion Dam including loading from both the Tuscarawas River and the local drainage from Goose Run. This information was combined with rainfall-frequency data and runoff analysis to obtain hydrologic risk information associated with interior flooding of Zoar Levee from all non-breach hydrologic loading sources. The results of these hydrologic investigations were used in computing the probability of loading for the existing risk condition. This information is contained in **Appendix A – Volumes I and II**.

3.1.3. Baseline Studies

Several baseline studies were undertaken during development of the DSMS to better understand the affected environment, benefits accrued by Zoar Levee & Diversion Dam, identify significant resources which are protected or otherwise regulated, help forecast the FWAC/No Action risk and to better define the potential consequences of a project failure. The following provides a summary of each study's purpose and contribution to the DSMS. These baseline studies are included in **Appendix D**.

3.1.3.1. Community Impact Baseline Study

To better understand Zoar Village and help identify potential impacts using the Other Social Effects (OSE) account under the 1983 Principles and Guidelines for Water and Land Resources Planning, Huntington District conducted a Community Impacts Baseline study. This study was critical to helping understand how and why Zoar Village functions and identifying significant economic, social and recreational resource constraints to consider when formulating, evaluating, and comparing alternatives (**Appendix D – Addendum 3**). This study was provided to the public and all stakeholders for review and comment before finalization.

3.1.3.2. Historic Property Baseline Study

Zoar Village is listed on the National Register of Historic Places (NRHP). To better understand this historic property, Huntington District assembled a baseline historic property study designed to re-evaluate the historical significance of Zoar Village, determine if the NRHP statement of significance, period of significance, and boundary require revision, and identify all contributing elements to this historic district. This report was also assembled to help define the Environmental Quality (EQ) account under the 1983 Principles and Guidelines for Water and Land Resources Planning. This study was provided to the public and all stakeholders for review and comment before finalization.

The baseline study is also designed to identify cultural resources qualifying for inclusion in the NRHP and develop a probability model for the presence of significant archeological sites. This data aided in identifying significant cultural/historical resource constraints to consider when formulating, evaluating and comparing alternatives. This study also aided Huntington District in complying with Section 106 of the National Historic Preservation Act (NHPA) and its regulating language, 36 CFR 800, which requires effects to historic properties be considered prior to approval of expenditure of Federal funds (**Appendix D – Addendum 1)**.

3.1.3.3. HTRW Phase I ESA

A Phase I Environmental Site Assessment (ESA) was conducted to determine what potentials for hazardous, toxic or radioactive waste (HTRW) may exist. This study utilized a search of existing records as well as interviews (**Appendix D – Addendum 5**). This study was provided to the public and all stakeholders for review and comment before finalization.

3.1.3.4. Net Benefits and Flood Damages Prevented Analysis

While Zoar Levee & Diversion Dam was not constructed to achieve traditional economic benefits, a structure inventory was developed within the protected area to be able to calculate depreciated replacement costs and help identify contribution to the National Economic Development (NED) accounts (**Appendix D – Addendum 4**).

3.1.3.5. Environmental Impact Baseline Study

A terrestrial and aquatic habitat baseline study was undertaken to identify any significant statutorily regulated environmental resources, including but not limited to wetlands and streams. This data helped to inform the formulation, evaluation and comparison of risk management alternatives and assisted in compliance with several specific resourced acts, including but not limited to the Clean Water Act. This report was also assembled to help define the EQ account under the 1983 Principles and Guidelines for Water and Land Resources Planning (**Appendix D – Addendum 6**). This study was provided to the public, federal and state resource agencies and all stakeholders for review and comment before finalization.

3.2. Existing Condition Risk

As previously discussed, risk is defined as the probability of inundation multiplied by the consequences. Three probabilities are discussed below:

1. The probability of inundation from failure or breach;
2. The probability of inundation from a pump station failure; and
3. The probability of inundation from overtopping of the levee or diversion dam.

Then a discussion of the existing condition of the leveed area is provided to:

1. Describe the affected environment;
2. Support development of the FWAC/No Action risk discussed in **Section 3.3**; and
3. Support the discussion of the consequences discussed in **Section 3.4**.

3.2.1. Probability of Failure or Breach

As discussed in **Chapter 1.0**, the purpose of this study is to obtain approval to modify the structures to address incremental risk associated with dam safety issues, utilizing USACE Tolerable Risk Guidelines to define what risks are unacceptable. Breaching of Zoar Levee & Diversion Dam is considered an incremental risk. To determine if the annual probability of a failure or breach is acceptable against the USACE Tolerable Risk Limit Line (TRLL), which is 1 in 10,000 annual chance of occurring, the following analysis was conducted.

First, it is important to understand how often Zoar Levee & Diversion Dam may be loaded with water, at various elevations. Zoar Levee is loaded with water impounded by Dover Dam. Zoar Diversion Dam is loaded by Goose Run. As discussed in **Section 3.1.2**, the following curves were developed to estimate the annual chance of water exceeding a certain elevation against the levee and diversion dam (see **Figure 3-1** and **Figure 3-2**, respectively). The X axis on these charts indicates the annual chance, expressed as 1 in N (e.g. 1 in 100). The Y axis on these charts indicates the level of water against the levee and the diversion dam. Solid lines represent the best estimates, while the dashed lines show a confidence band to encompass the uncertainty.

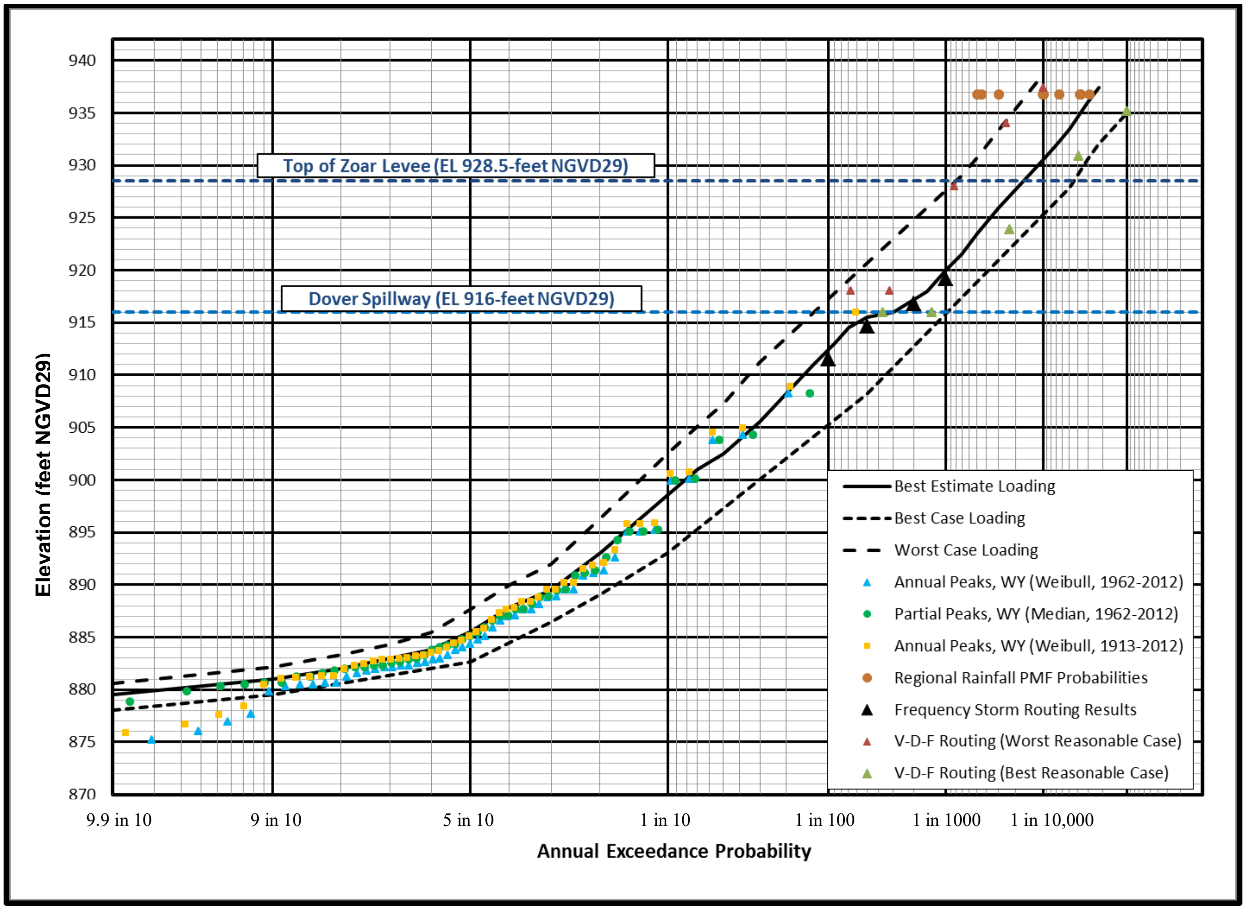

Figure 3-1 Zoar Levee hydrologic loading from Tuscarawas River.

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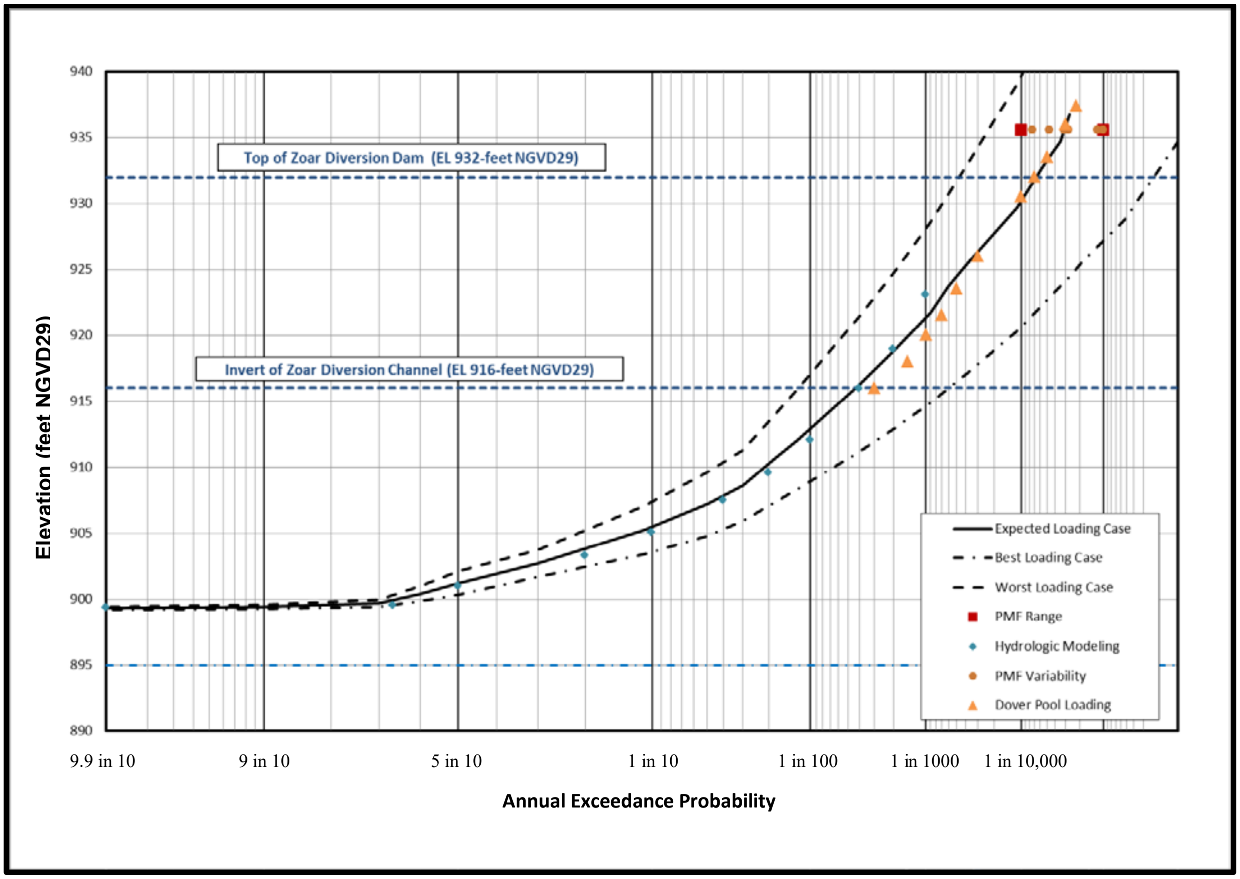

Figure 3-2 Zoar Diversion Dam hydrologic loading from Goose Run

Second, a team of experts then evaluated how well they believed the levee or diversion dam would perform with different levels of water against them. This is also referred to as "system response." Specifically, the following was accomplished:

- A Potential Failure Modes Analysis (PFMA) was conducted to brainstorm all credible ways the levee and diversion dam could fail. The first list of PFMs was then narrowed down during discussions to those that significantly contribute to project risk.
- A total of six significant PFMs were identified for the levee. A total of 4 significant PFMs were identified for the diversion dam. Significant PFMs were concerned with: (a) seepage through foundation soils; (b) seepage through bedrock at the Rock Knoll Reach and the diversion dam; (c) overtopping; and (d) seepage along project conduits. For descriptions of each of the PFMs, see **Appendix A – Volume I**.
- This final array of significant PFMs was then broken down to identify specific events that must occur for them to actually cause a failure. These events are referred to as nodes on an event tree.
- A Team Elicitation was performed to assign numerical probabilities to all the events that must occur for each PFM to progress to full breach of the levee or diversion dam. The result was the series of curves presented in **Figure 3-3**, **Figure 3-4** and **Figure 3-5**. Each

curve, referred to as a "System Response Curve" represents a significant PFM. The X-axis displays the chance the levee could fail given a certain water loading (Y-axis). The team also estimated the amount of uncertainty in their assigned probabilities, but for clarity the plots below only represent the "best estimate" values. The team also estimated how emergency action could change the probability of failure. The plots below only represent the estimated probabilities without any intervention. For a full documentation of this process and description of the PFMs, including estimated probabilities that account for the possibility for successful intervention, see **Appendix A – Volume I.**

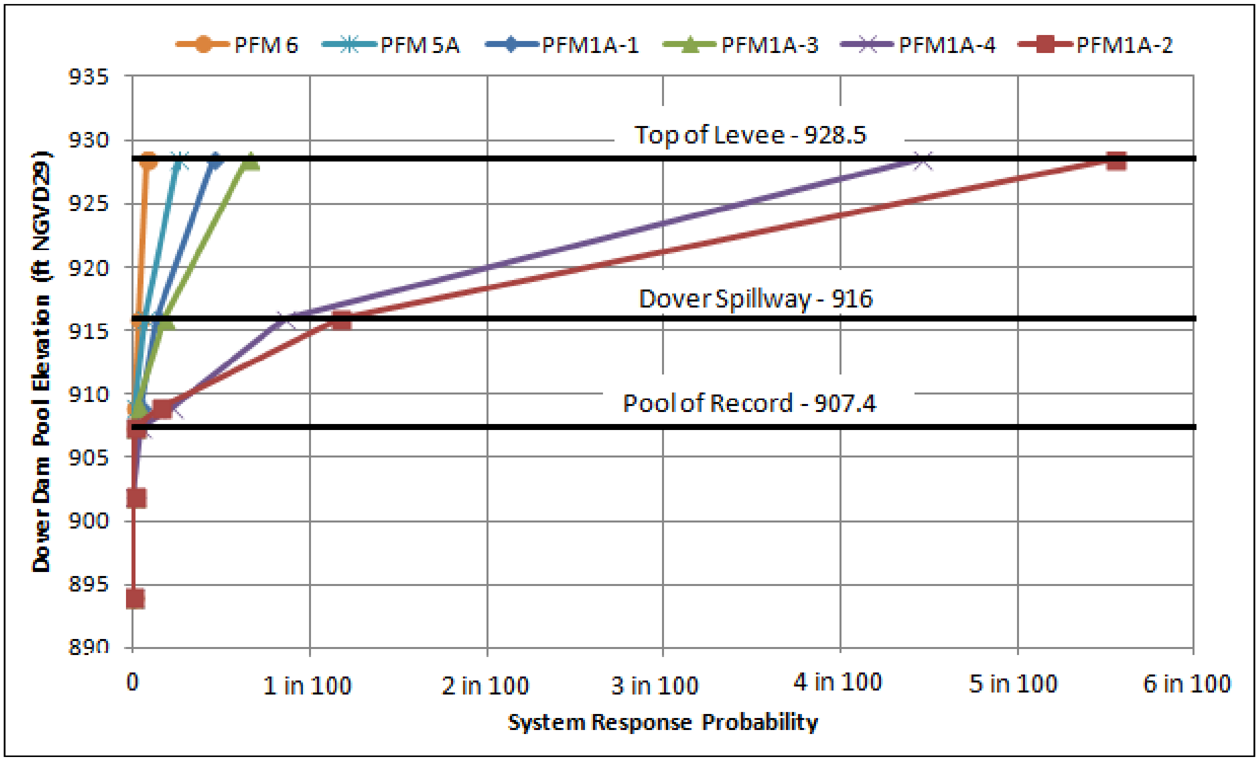

Figure 3-3 System Response Curves for Zoar Levee (no intervention)

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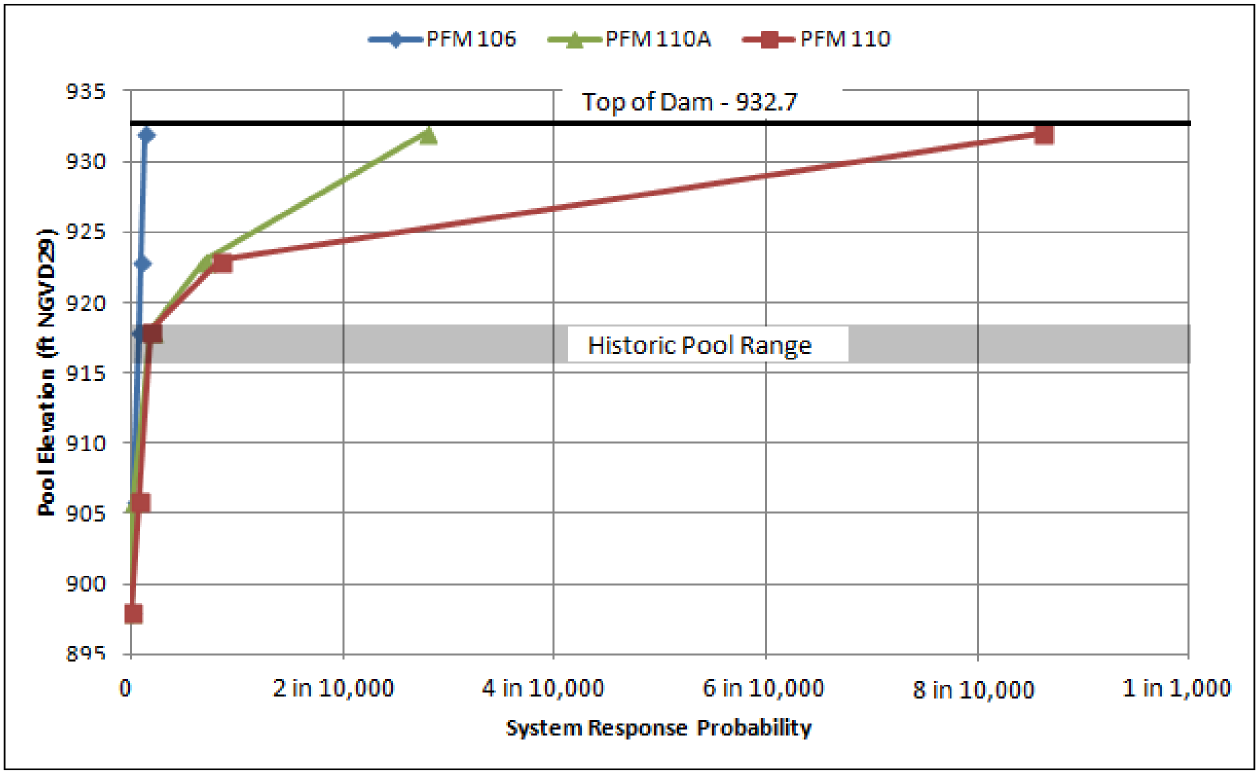

Figure 3-4 System Response Curve for Zoar Diversion Dam non-overtopping PFMs (no intervention)

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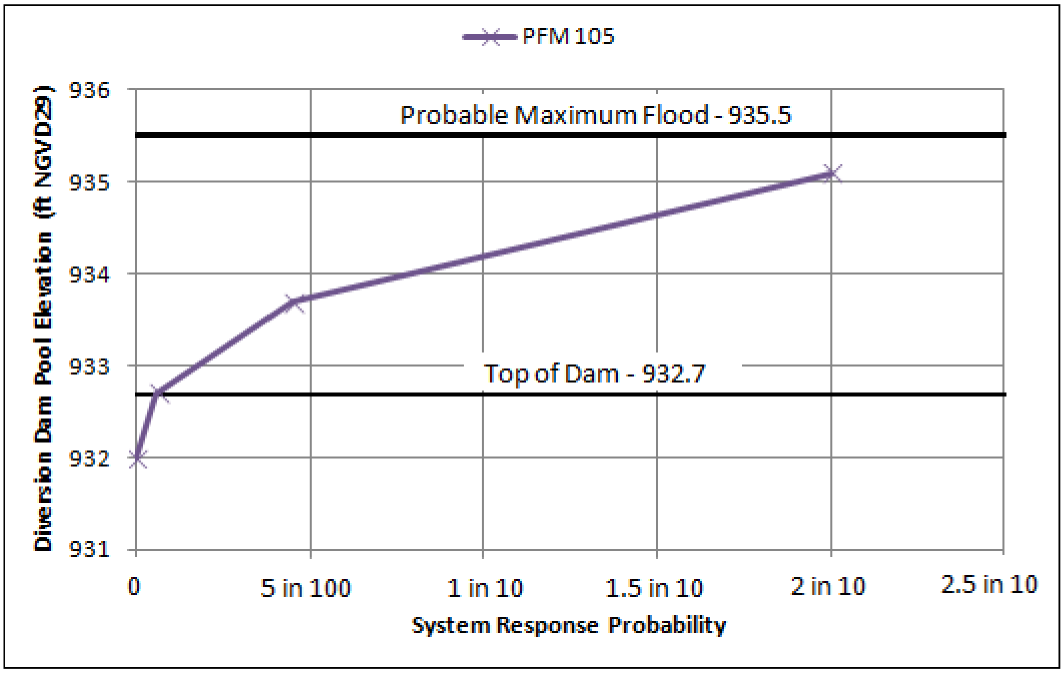

Figure 3-5 System Response Curve for Zoar Diversion Dam, overtopping w/breach (no intervention)

Using this information, the annual probability of failure for each significant PFM was calculated. These are displayed in **Figure 3-6**. The best estimates are symbolized with "○". Ranges of uncertainty are provided for levee PFMs 1A-1, 1A-2, 1A-3, 1A-4, and 5A with the bars that extend above and below the "○". Ranges of uncertainty were not estimated for PFM 6 or the diversion dam PFMs.

As can be seen, the estimates for annual probability of failure have a significant amount of uncertainty. The biggest driver of the uncertainty was the geology underneath the levee. Given the dynamic geologic history at this location, it is difficult to know with certainty what types of conditions exist underneath the levee, especially along the Ball Field Reach. The nature of the types of deposits, where they are located, and how they relate to the levee are key to assessing the risks for this project.

The X-axis in **Figure 3-6** represents each PFM. The Y-axis represents the probability of that PFM occurring in a given year, or the annual chance of occurring. Those PFMs in red, when uncertainty was considered, were above USACE TRLL for annual probability of failure, which is 1 in 10,000.

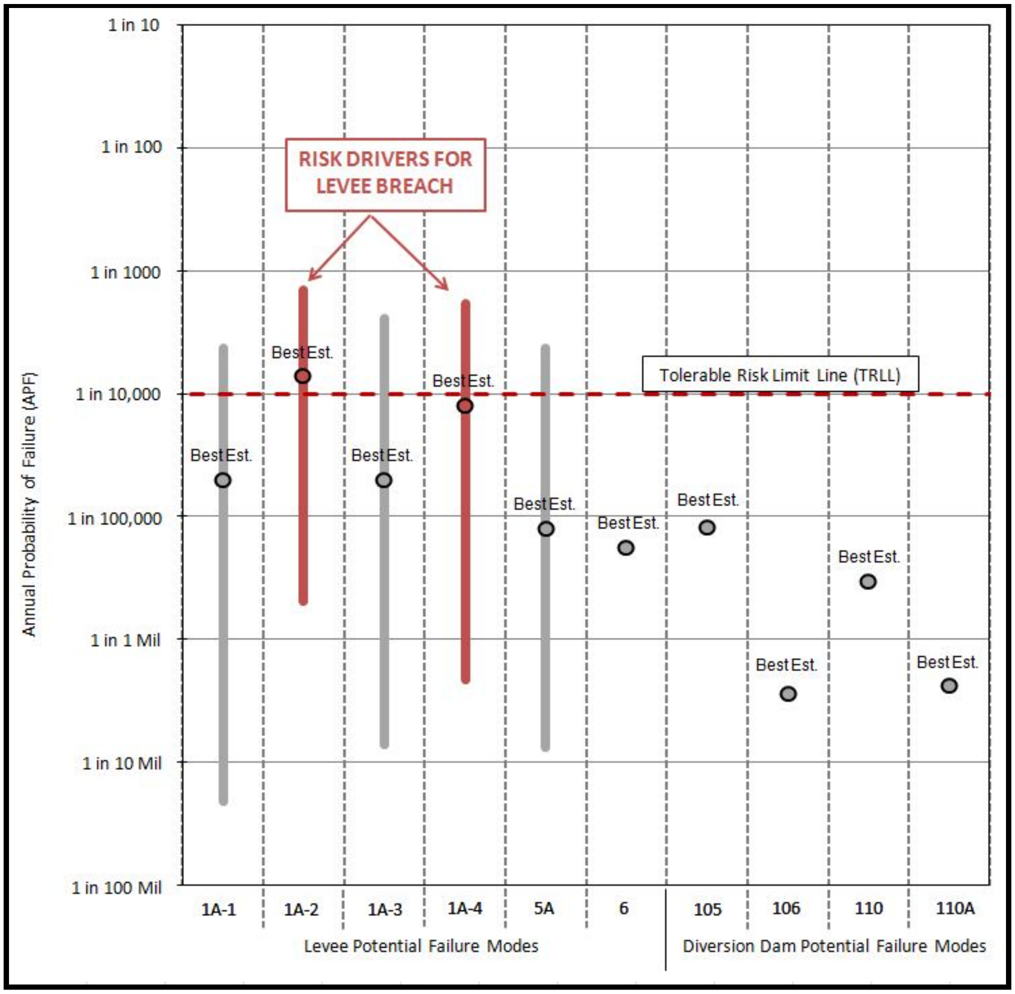

Figure 3-6 Annual Probabilities of Failure by PFM, Zoar Levee & Diversion Dam (no intervention)

Total annual probabilities of failure for the levee and diversion dam are shown below in **Figure 3-7**. As discussed in Appendix N, observations from an interior rainfall event that occurred in August 2014 indicates a possibility that risks at the diversion dam may be slightly higher than estimated. However, it has been decided that these risks are unlikely to approach the TRLL; and were, therefore, not re-elicited. The dots in red represent the probabilities which are above USACE TRLL. Pump failure and overtopping are discussed in **Sections 3.2.2** and **3.2.3**, respectively.

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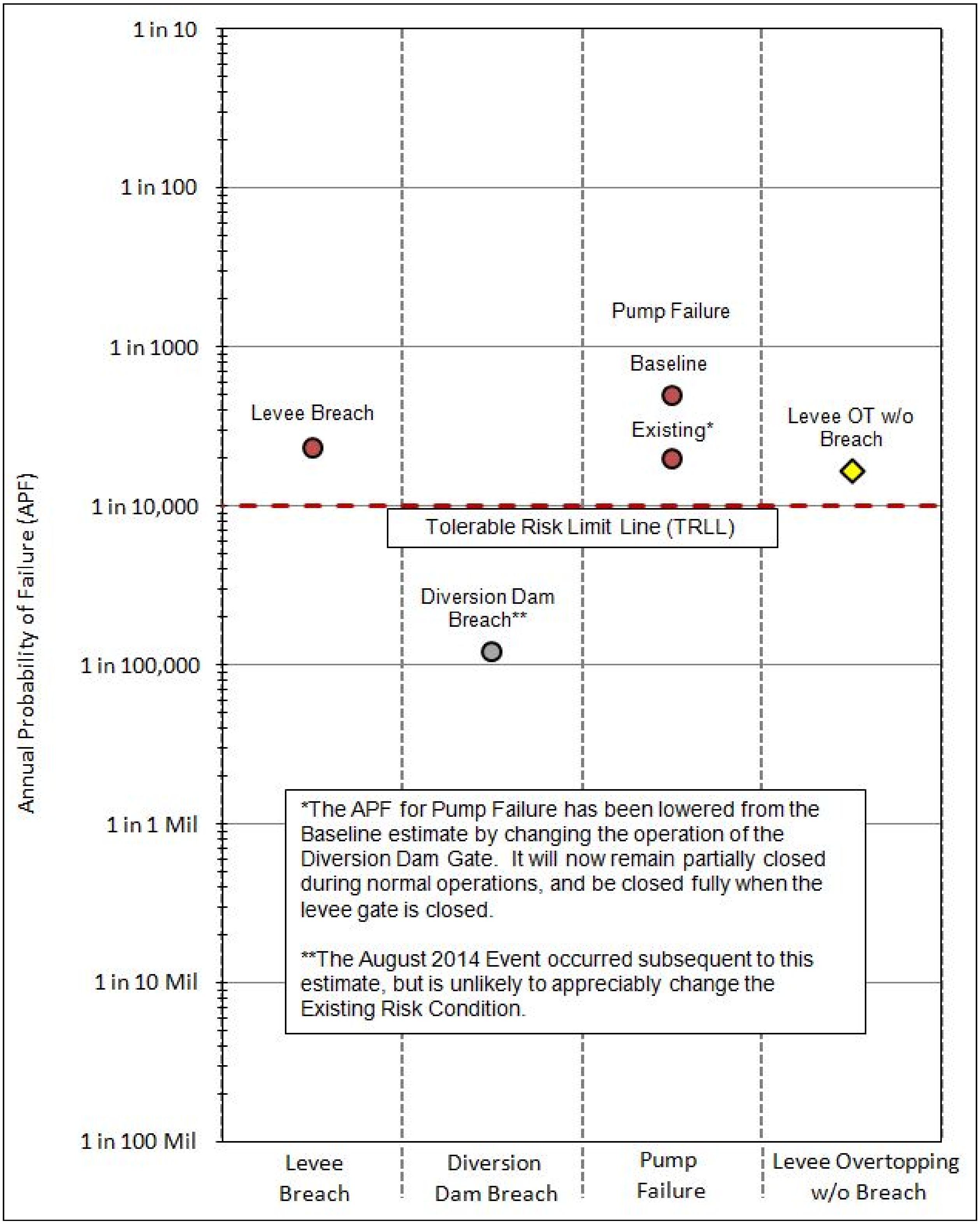

Figure 3-7 Annual Probabilities of Failure totaled, Zoar Levee & Diversion Dam (no intervention).

As will be discussed in **Section 3.4.1**, the risk in terms of life loss (average annual incremental life loss) or economic damages (annualized incremental economic consequences) were found to fall well within the acceptable threshold when compared to the USACE Tolerable Risk Guidelines.

As charted on **Figure 3-6**, PFM 1A-2 and PFM 1A-4 are the risk drivers of annual probability of breach at the levee. These PFMs focused on risks associated with underseepage through the deep pervious foundation soils at the Ball Field Reach and ponding area, respectively (see **Figure 3-8** below).

Figure 3-8 Oblique aerial from January 2005 Event showing locations on Zoar Levee associated with PFM 1A-2 & PFM 1A-4.

Reducing the probability of failure from these two PFMs is therefore essential to meet the purpose and need to reduce and manage incremental risks that do not meet USACE Tolerable Risk Guidelines.

3.2.1.1. PFM 1A-2 Ball Field Reach

PFM 1A-2 is a scenario along the Ball Field Reach where:

- The River-Side of the levee is loaded with water;

- Water then infiltrates beneath the levee (called underseepage) due to the pervious nature of the underlying soils;
- This underseepage tries to exit at the surface on the Village-Side of the levee;
- The ground surface of the Village-Side of the levee is covered with an impervious layer of soil, called a confining layer, because it confines or tries to resist the water from coming to the surface;
- As the water level raises against the River-Side of the levee, the pressures pushing water up against the confining layer on the Village-Side become greater;
- Finally, the confining layer cracks and water begins to exit on the ground surface of the Village-Side of the levee. This exit point is sometimes referred to as a boil;
- The soil directly below the confining layer is a uniform sand that begins to erode out of the boil;
- As the sands erode out, the confining layer does not collapse to fill in the resulting void (provides roof support);
- This allows a pipe or channel to begin to erode backwards from the Village-Side to the River-Side;
- There is no change in the nature of the uniform sand or its direct contact with the confining layer to stop or arrest these pipes or channels from connecting the Village-Side to the River-Side;
- These pipes or channels grow and connect (enlarge), basically eroding the foundation from underneath the levee; and
- The levee collapses under its own weight and a breach occurs.

This phenomenon is defined as backward erosion piping (see **Figure 3-9** below). For a more technical and thorough discussion of the processes associated with backward erosion piping and PFM 1A-2, refer to **Appendix A – Volume I**.

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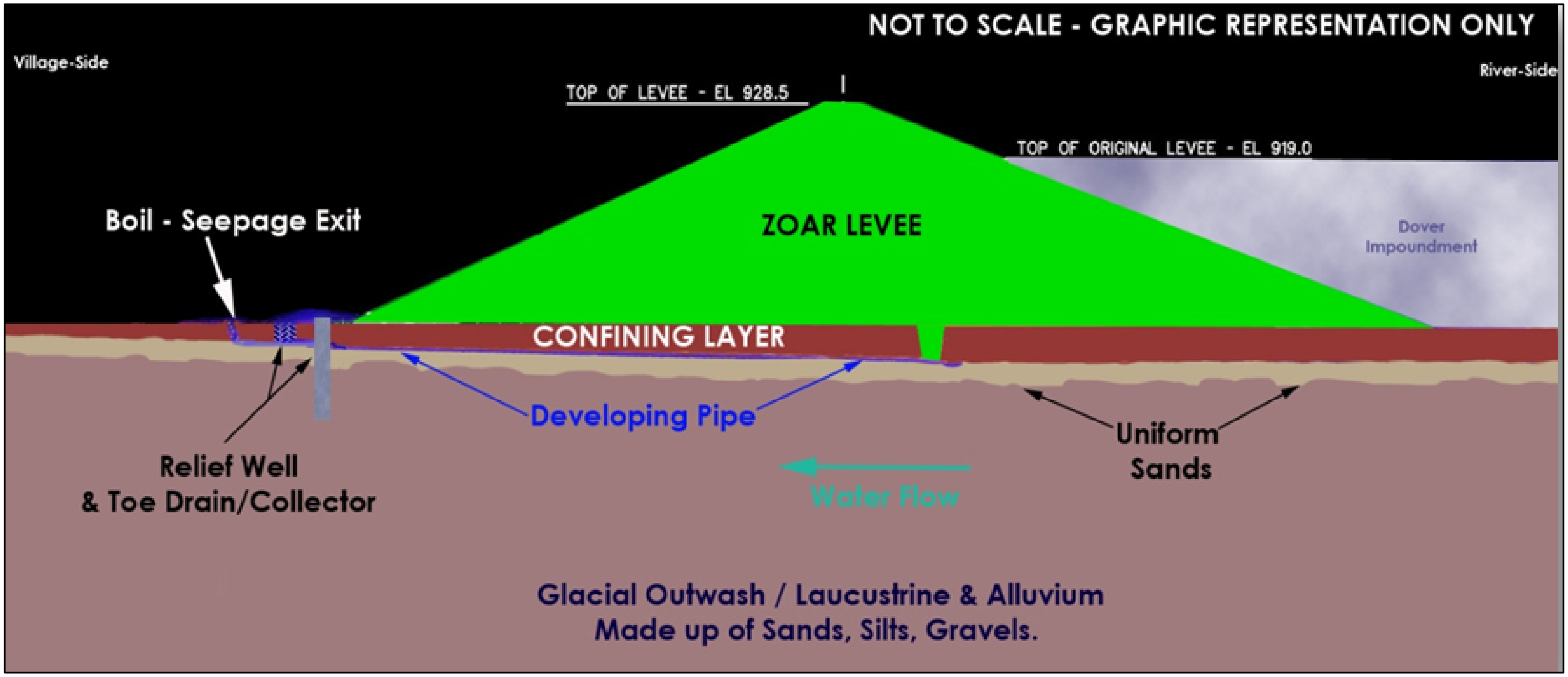

Figure 3-9 Graphic cross section of Zoar Levee demonstrating PFM 1A-2 scenario.

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The best estimate for annual probability of failure for PFM 1A-2 is 1 in 7,200 chances each year, just above the USACE TRLL for annual probability of failure. Therefore PFM 1A-2 needs to be addressed to meet the purpose and need for Federal action.

3.2.1.2. PFM 1A-4 Ponding Area

PFM 1A-4 is a scenario specific to the ponding area located adjacent to the pump station; but is generally concerned with the same backward erosion piping discussed for PFM 1A-2. The only significant difference was in the confining layer for PFM 1A-4 and its ability to resist the water pressure as the water rises on the River-Side of the levee. Otherwise, the process outlined for PFM 1A-2 is similar for PFM 1A-4.

The best estimate of annual probability of failure is 1 in 12,300 chances each year. While this estimate is just below the USACE TRLL for annual probability of failure, the proximity to the TRLL, when combined with the uncertainty surrounding PFM 1A-4, indicates it needs to be addressed to meet the purpose and need for Federal action.

3.2.2. Probability of Inundation from Pump Failure

Additional inundation risks from interior drainage have the potential for similar consequences as those that would occur with a levee breach. To estimate these probabilities, an analysis was undertaken to determine if seepage (including seepage collected by the current relief wells and toe drain), flow from Goose Run, and interior stormwater could combine to overwhelm the pump station, shutting down the pumps and allowing the leveed area to begin to fill with water. **Appendix A – Volume II** documents the process for estimating the annual probability of this occurrence. The resulting best estimate of annual probability of pump failure was 1 in 2,030 chances each year which is above the USACE TRLL (refer to **Figure 3-7** above). Analysis indicates misoperation of the diversion dam sluice gate, the undersized diversion channel culvert, and malfunction of the pump station were the risk drivers. Following completion of the baseline risk estimate, an interior storm event occurred in August of 2014 that indicated that it would be prudent to partially lower the diversion dam sluice gate for normal operations to lower the risk of pump inundation (**Appendix N**). This change has been made, which lowers the existing estimate of annual probability of pump failure to 1 in 5,080 chances each year, which is still above the USACE TRLL (refer to **Figure 3-7** above).

Therefore, probabilities of pump failure need to be addressed to meet the purpose and need for Federal action.

3.2.3. Probability of Inundation from Overtopping from Levee

Overtopping of the levee was identified as the most likely contributor to inundation risk, in that there is a 1 in 6,000 chance each year this could occur. However, a breach resulting from overtopping is unlikely due to the levee composition and rapid filling of the interior. Therefore, addressing inundation risks associated with overtopping does not fall within the purpose and need of this study.

That being said, it is important to recognize the annual chance of overtopping is above the USACE TRLL for annual probability of failure (**Figure 3-7**), and it will continue to be the most likely inundation risk even if a dam safety modification is implemented.

3.2.4. *Existing Condition of Affected Environment

The following provides an understanding of the existing condition of the leveed area and its surroundings (affected environment) to help forecast the FWAC/No Action scenario in **Section 3.3** and inform the consequences in **Section 3.4**.

A study area surrounding Zoar Levee & Diversion Dam was established as it pertains to specific resource types, such as social, recreational, historical/cultural, hazardous, economic and environmental resources. This data also provided an inventory of significant or regulated resources to help identify any impacts to the human environment which may occur from alternative risk management plans.

The study area was designed to capture the known limits of the Zoar Village Historic Site, or the portion of the Village operated as an interpretive historic site open to the public, the incorporated limits of Zoar Village and all features associated with Zoar Levee & Diversion Dam. **Figure 3-10** characterizes the general nature of the study area.

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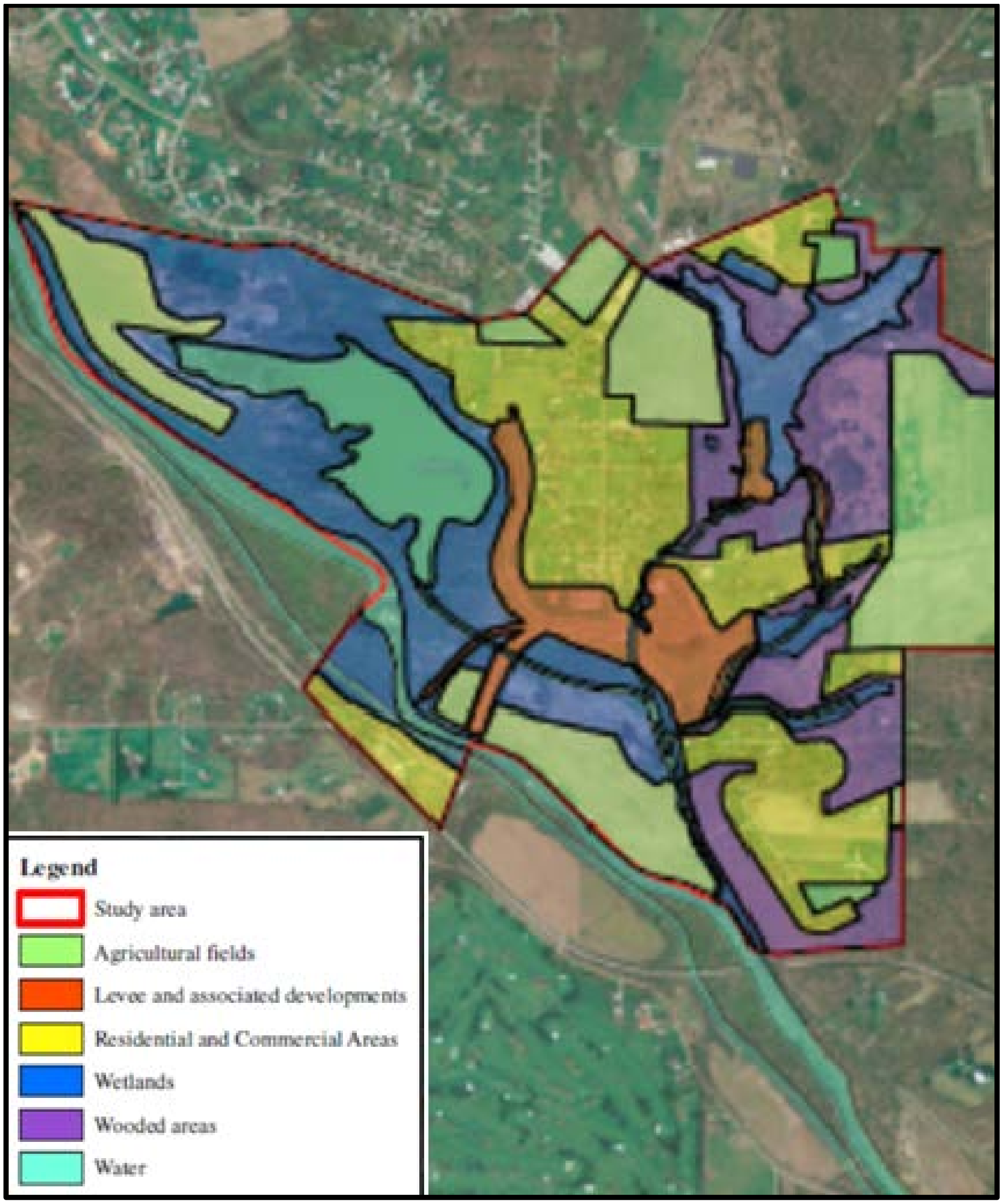

Figure 3-10 Study area. See Appendix D – Addendum 1 for more resolution.

The focus of this discussion is on Zoar Village, as it is the most significant part of the affected environment; although other resources are also summarized.

3.2.4.1. Zoar Village (Social, Economic, Recreational, and Cultural/Historical Resources)
Zoar Village community and the Zoar Village Historic Site share a common heritage dating back into the 1800s. Zoar was established in 1817 as a productive, rural and communal community. Later in the 19th century, Zoar evolved into a historic storehouse of unique architecture, rich cultural heritage and a close-knit society. Today it operates as a living community which closely

relates to and relies upon its historical significance to remain a viable place to live and work, as well as provide the region with a valued heritage and recreational asset. As will be discussed below, the construction of Zoar Levee & Diversion Dam enabled the continued survival of Zoar Village and the development of the Zoar Village Historic Site in the 20^{th}-21^{st} century.

The benefits of Zoar Levee & Diversion Dam are best captured qualitatively through the EQ and OSE accounts. Therefore, the following provides a description of social, economic, recreational and cultural/historical resources within the affected environment. A comprehensive history and understanding of Zoar Village can be found in **Appendix D – Addendum 1**.

Zoar Village was established in 1817 by a group of German separatists seeking a new home where they could freely practice their religion without oppression. They called themselves the Society of Separatists of Zoar. In 1819, the community voted to adopt a communal lifestyle in order to establish security and prosperity. They established a European-style village, where most of the population lived in a centralized area (**Figure 3-11**) (much of which survives today) and then worked the surrounding land for agriculture and resource extraction.

Following the dissolution of the Society of Separatists in 1898, Zoar Village, its historical integrity and the community slowly declined, becoming a residential home to nearby factory workers. In the 1930s, recognition that Zoar's historical integrity was at risk from both construction of Dover Dam and slow degradation mobilized both local and state historical groups to begin to invest in purchasing and slowly restoring significant buildings in the community, ultimately turning it into a State Memorial Site (Zoar Village Historic Site) and lobbying the Federal government and MWCD to build Zoar Levee & Diversion Dam rather than raze the village.

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Figure 3-11 Roof-top view of Zoar Village from 1888.

External investment in restoring the historical integrity of the community continued during the 1950s and 1960s. In the 1950s the Federal government increased the level of protection to the historical site by adding seepage control features and raising the levee height.

In 1996, Congress designated the Ohio & Erie Canalway a "National Heritage Area", one of 49 in existence. According to the Ohio & Erie Canal Coalition (OECC), Zoar Village played a critical part in securing the National Heritage Area designation. Since receiving this designation, the OECC has administered in excess of $500,000 in Federal grants that have benefited Zoar Village.

During the first decade of the 21st Century the Zoar Village Historic Site has thrived. A local entity, the Zoar Community Association (ZCA), is now under contract to manage and operate tours of several of the buildings in Zoar Village for the Ohio History Connection (OHC), which was formerly known as the Ohio Historical Society (see **Figure 3-12** below). This agreement has increased community cohesion and ownership in the Zoar Village Historic Site as well as helped to integrate the success of the community as a living village and historical site. This arrangement has also helped outside influences, such as OHC and OECC to focus their time and attention on maintaining the buildings and removed the responsibility of hosting tours and festivals. As a result, Zoar Village has become a desirable place to live and operate businesses designed to attract tourism.

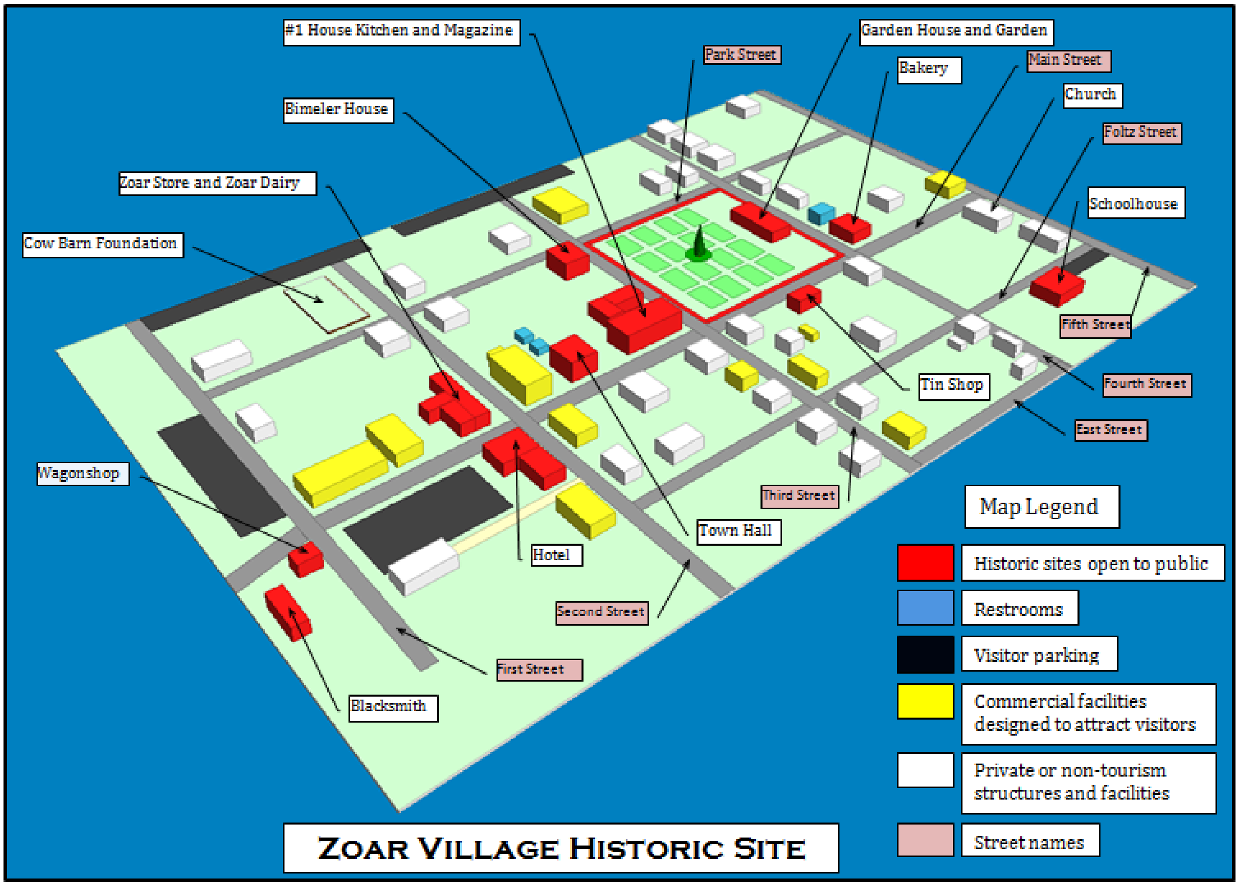

Figure 3-12 Zoar Village Historic Site.

Tourism and recreation play major roles in the success of Zoar Village as a viable place to live and recreate and are vital to sustaining the historic site. Between 2001 and July 2012, 114,226 people visited Zoar Village and the ZCA has earned a combined total of $523,000 in revenue from its stores, programs, and events. This is a substantial figure when compared to the income received over the same period from the ZCA's two other main sources: 1) membership ($57,000) and 2) contributions and grants ($275,000) (see **Appendix D – Addendum 3**). Between 1999 and 2011 the ZCA reports approximately $900,000 was granted to Zoar Village for the restoration of buildings and other interpretative improvements (Jon Elsasser Personal Communication 2011). In 2001 the Tuscarawas County Convention and Visitors Bureau estimated Zoar Village's tourism contributed over $10.5 M to the local economy. For a complete list of major festivals and the tourism industry see **Appendix D – Addendums 1 and 3**.

Other recreation resources related to the tourism industry also fall within the affected environment (see **Figure 3-13** below). Portions of Federal land located along the toe of the Ball Field Reach are out-granted to the State of Ohio and Zoar Village. Both have constructed parking facilities on the out-grants which offer tourists and visitors places to park and recreate.

Zoar Village has established a Little League Ball Field (for which the Ball Field Reach is named) within the extent of the leased land. These out-granted areas serve as passive barriers between the Zoar Village Historic Site and the levee. Some trees have been planted in these areas. Additionally, the gravel parking lot built by Zoar Village has lighting, a picket fence, and kiosks.

As will be discussed in **Chapter 5.0**, the existing condition for these resources under the terms of the out-grant agreements includes that these areas are available at the convenience of the Government.

The State of Ohio also owns two parking lots adjacent to the areas out-granted to them (A & C on **Figure 3-13**). During major festivals Zoar Village uses a fallow field north of town to offer additional parking to visitors. Additionally, while most festivals and events take advantage of the entire village, a grass field located adjacent to 5^{th} Street is used to set up festival tents.

Earth Action Partnership, a non-profit organization which works with the ZCA to highlight Zoar Village's recreational value, operates and maintains the Zoar Wetland Arboretum. The Arboretum is an artificial impoundment and wetland located just west of Zoar Levee which provides ecological and outdoor recreation.

In addition, OECC has constructed an approximately 90 mile long bike trail along an old toe path of the Ohio & Eric Canal, which follows the Tuscarawas River and passes directly by Zoar Village. Zoar Village and OECC operate these facilities in concert.

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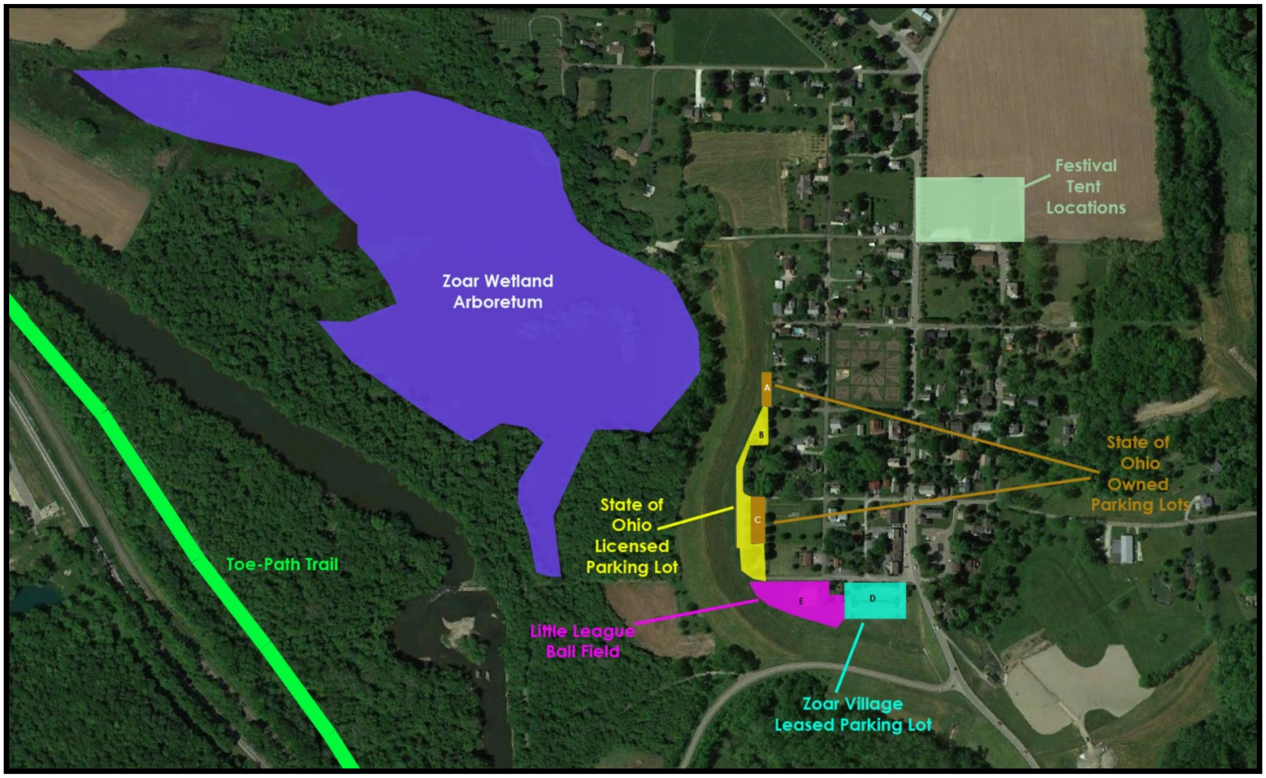

Figure 3-13 Other recreational resources.

The leveed area has become the heart of a nationally significant historical site with excellent historical integrity (see **Appendix D – Addendum 1**). Zoar Village was compared to remains of four communal settlements listed in the NRHP which were judged to be similar in organization and religious outlook: The Harmony Society, the Amana Society, the Aurora/Bethel societies, and Bishop Hill Colony. In comparison with these four societies, Zoar Village is notable for its high density of historic buildings dating to the period of significance; its integrity today is almost unparalleled in comparison to these other communities and historic sites (see **Appendix D – Addendum 1**).

The Zoar Village Historic Site, which is managed by the OHC was placed on the NRHP in 1969 (Pratt 1969). The NRHP boundary was revised in 1975. The NRHP is the official list of the nation's historic places worthy of preservation and was authorized by the National Historic Preservation Act of 1966. The community was listed under Criterion A for its association with the 19th century German separatist movement and under Criterion C for its outstanding examples of 19th century architecture. As currently listed, its period of significance extends from 1817 to 1898. Period of significant refers to the length of time when a property was associated with important events, activities, or persons, or attained the characteristics which qualify it for NRHP listing. Most of the built environment in the leveed area dates to the period of significance. In 2013 the OHC resubmitted a revised NRHP nomination to the National Park Service in the hopes of securing a National Historic Landmark (NHL) designation for Zoar Village. NHLs are nationally significant historic places designated by the Secretary of the Interior because they contain exceptional value or quality in illustrating or interpreting the heritage of the United States. Zoar Village is currently slated to be reviewed for NHL status in the summer of 2016.

The historic property baseline study conducted in 2013 recommends a larger NRHP boundary for Zoar Village, identifying all the contributing resources within that boundary (**Figure 3-12**). The proposed 2013 Zoar Historic District is nationally significant under all four NRHP criteria. Eighty-nine Separatist resources have been identified, of which 88 are recommended as contributing to a proposed 2013 Zoar Historic District (see **Appendix D – Addendum 1**).

This recommended NRHP revision includes a revised period of significance (1817-1962) to encompass development of significant events such as the investment made to build Zoar Levee & Diversion Dam and then to create and operate a historical recreation site. Seven non-Separatist resources have also been recommended eligible for the proposed 2013 Zoar Historic District because they exemplify one or more broad patterns in American history (**Figure 3-14**). The seven resources fall within the following contexts: Commerce and Industry, 1898–1962; Transportation, 1898–1962; Flood Control Efforts, 1898–1962; and Preservation Efforts, 1898–1962 (see **Appendix D – Addendum 1**).

In consultation with the Ohio State Historic Preservation Office (OHPO) Zoar Levee & Diversion Dam is also considered eligible for inclusion in the NRHP, as a contributing element to the Muskingum Basin Flood Risk Management Historic District.

Comprehensive archeological investigations in and around Zoar Levee & Diversion Dam have not been conducted. However, probability models indicate the likelihood of archeological resources existing within the general area is high; especially for the historic period as it relates to the Society of Separatists. However, a disturbance assessment indicates areas directly adjacent to the levee are likely to be disturbed reducing the potential that archeological sites qualifying as historic properties, exist in this zone (see **Figure 3-15** below) (see **Appendix D – Addendum 1**).

It is notable that the Society of Separatists occupied many thousands of acres surrounding Zoar Village. The historic property baseline study identified the limits of this ownership as well as the possible locations of other cultural resources which may survive that are associated with the Society of Separatists (see **Figure 3-16** below) (see **Appendix D – Addendum 1**). While these resources are not nearby Zoar Levee & Diversion Dam, they may fall within an area of potential effects for indirect impacts.

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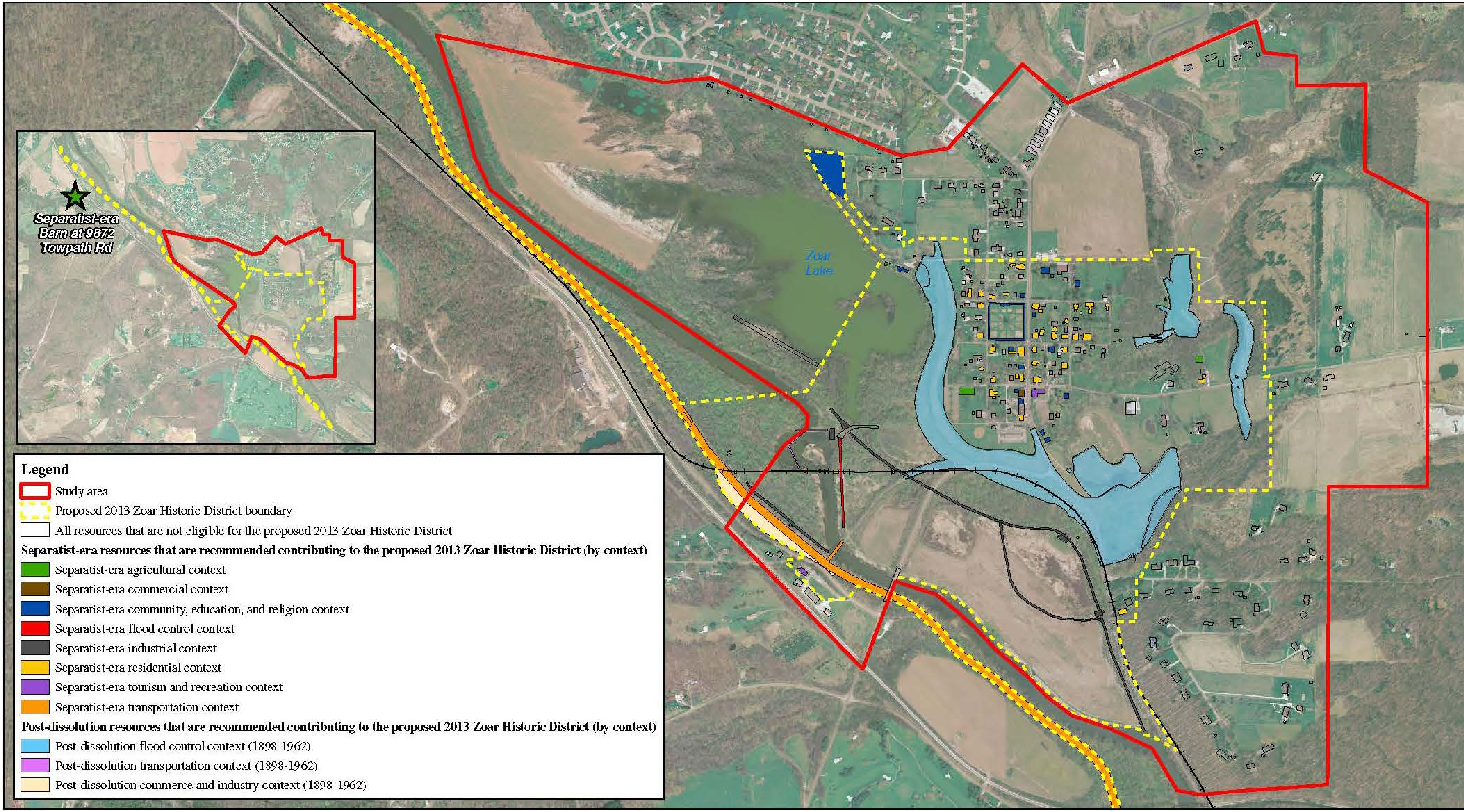

Figure 3-14 Proposed 2013 Zoar Historic District identifying contributing resources by theme. See Appendix D – Addendum 1 for more resolution.

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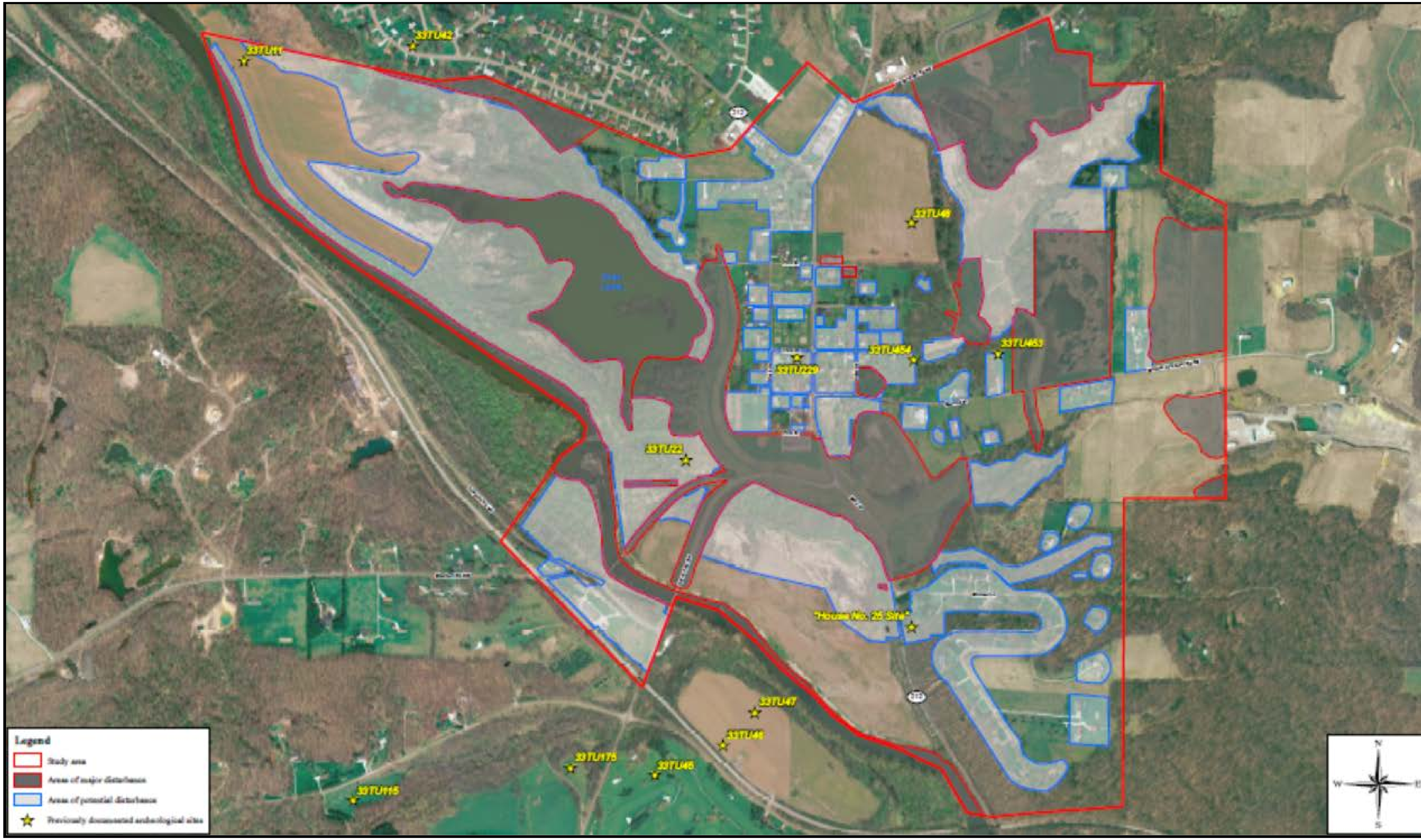

Figure 3-15 Disturbance assessment surrounding Zoar Levee & Diversion Dam. See Appendix D – Addendum 1 for more resolution.

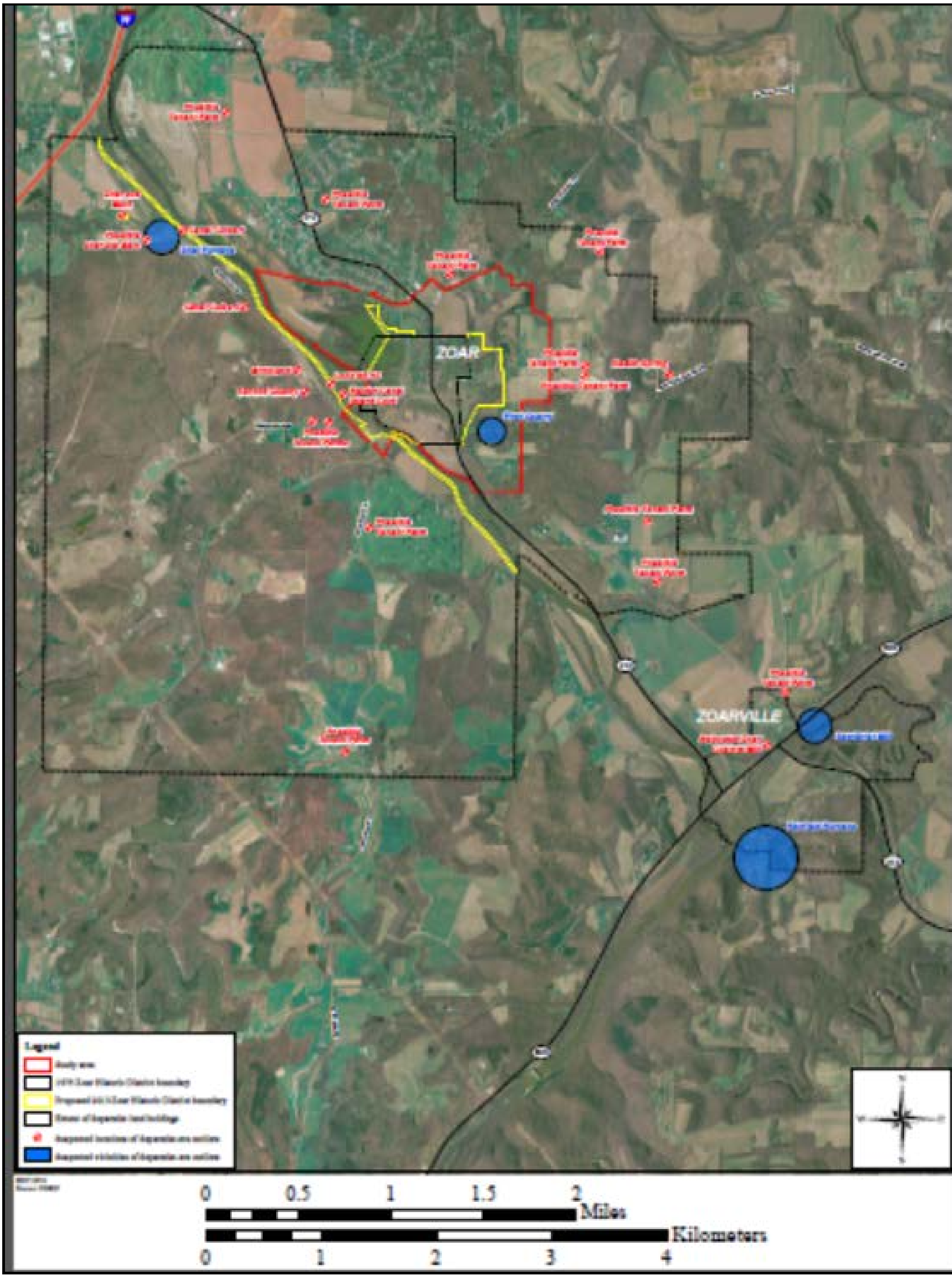

Figure 3-16 Approximate extent of landholding of Society of Separatists. See Appendix D – Addendum 1 for more resolution.

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In 2013, Zoar Village's (see **Figure 3-17** below) population of 169 persons was composed of 88 males and 81 females. This population was residing within 77 households whose mean income was $80,625 in 2010, a figure which exceeds both county (Tuscarawas County - $42,081) and state (Ohio - $63,477) household incomes. The largest age bracket in numbers of people was between 65 and 69 years old (n=21) and approximately 55% of the total population of the community was between 45 and 69 years old. The median age of the community was 52.6 years old compared to the median age in Tuscarawas County at 40.9 years old. Zoar is a relatively older community and is wealthy as measured by per capita income when compared to the per capita income figures of the county and the state (Zoar - $39,911, Tuscarawas County - $20,536, State - $25,618). The population is well educated with 92.5% of the residents having graduated high school and 34.2% having bachelor's degree or higher (see **Appendix D – Addendum 3**).

Zoar Village has had a relatively stable housing market since the 2000 Census with owner-occupied housing composing 87% of all units. Demographic data shows the median value of owner-occupied housing units has increased in value by $44,000 since 2000. The percentage of housing units valued over $200,000 increased from 16% to 37% in ten years.

Zoar Village is successful because it is largely populated and repopulated by recently retired or a second-career generation of energized individuals with the interest to live and participate in a community whose success and identity is highly connected to its historical significance. The two 'halves" of the Village (e.g. historic site and people) remain highly interconnected and are enhanced by civic participation; external support and volunteerism (see **Appendix D – Addendum 3**).

Zoar Village's success as a functional community is tied to its historical identity and tourism industry. If the historical site were to lose its value, the community may no longer thrive and a loss of community interest and participation would lead to a significant decline in the integrity of Zoar Village as a historic site and heritage and recreation asset (see **Appendix D – Addendum 3**).

This symbiosis combines to allow Zoar Village to function as a fiscally-solvent jurisdiction thanks in large part to its heritage-based tourism, which is successful thanks to a partnership between local residents as well as significant investments by outside groups (**Figure 3-18**). This is despite significant challenges such as its small size, population and limited tax base (see **Appendix D – Addendum 3**).

For more information concerning Zoar Village or the Ohio & Erie Canal National Heritage Corridor, please see **Appendix D** and/or visit http://historiczoarvillage.com/, http://www.ohiohistory.org/museums-and-historic-sites/museum--historic-sites-by-name/zoar-village, http://zoarwetland.org/ or www.ohioeriecanal.org.

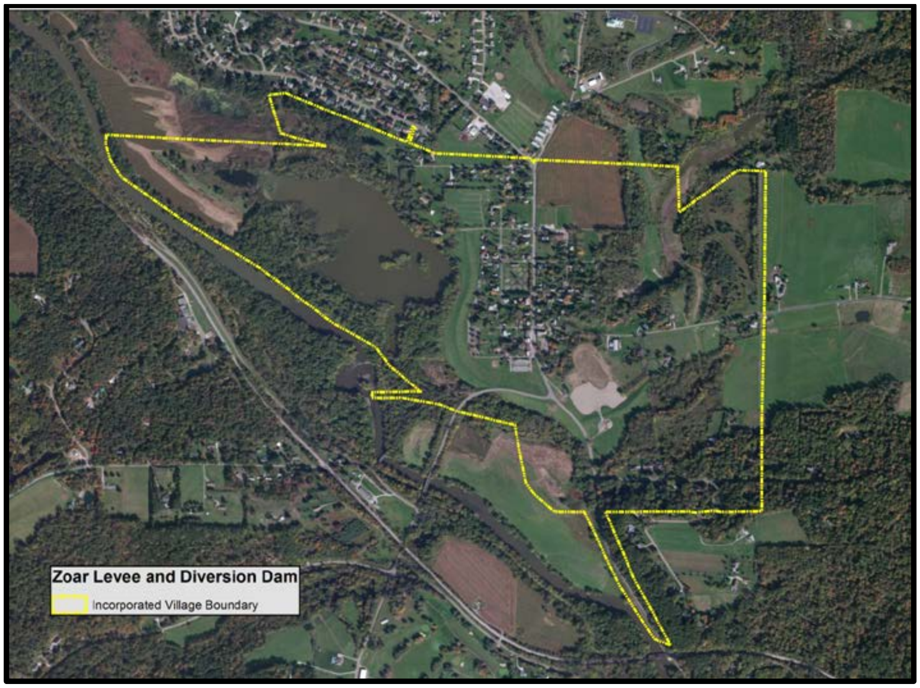

Figure 3-17 Zoar Village incorporated limits.

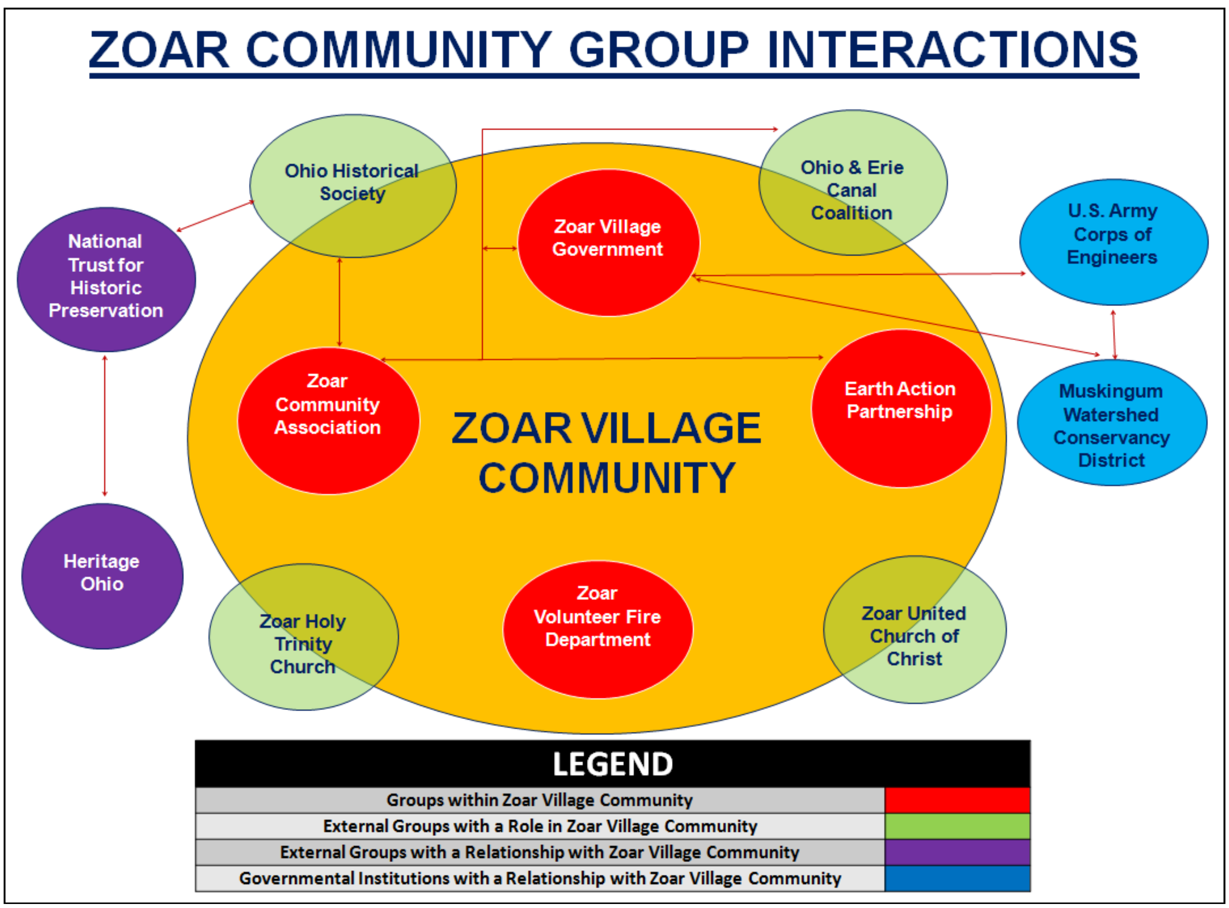

Figure 3-18 Zoar community group interactions.

3.2.4.2. Societal Concerns

Risks associated with living behind Zoar Levee are not a new concept to Zoar Village. The levee has experienced seepage related interior flooding in the past. The most significant event occurred in 1947, when a then record pool elevation of 902.7 feet was impounded outside of the levee and no seepage control features had been put in place. This and other events, including in 1952, 1959, 2005 and 2011 have led to standing water in basements, as well as water ponding within the Ball Field and Rock Knoll Reaches. No reports of flooding above first-floor sills have been documented. Structural damage has occurred due to pumping water from basements, but investments have been made to repair major damage. None of these past events, including the March 2008 Event, when emergency action was required, seem to have had a significant impact on the growth of the village or the perception of intolerable risks. These concerns have been mitigated by actions taken by USACE following events, including but not limited to raising the levee, adding a pump station, adding relief wells and more recently, adding several million dollars in IRRMs.

Between 1947 and 2011, the housing market continued to grow, homes were bought and sold, new residents joined the community and external investment in repairing, upgrading and operating and maintaining the historic site continued.

A 2010 Comprehensive Plan prepared by Zoar Village demonstrates a strong positive outlook on the future. The plan did not even mention Zoar Levee & Diversion Dam and certainly did not identify it is a current or future threat to community growth and viability.

The understanding of risk changed in 2011 when the DSMS was announced. In particular, the awareness that "removal of the levee" would have to be considered has caused significant concern that the Federal government would find it more efficient to acquire and vacate the leveed area rather than manage the risk through rehabilitation. Perception of continued prosperity was also negatively reinforced when USACE, due to recent performance issues, could not provide a positive LSE without further analysis and perhaps action. As a result, FEMA de-accredited the project against the base flood.

Since the DSMS was announced in 2011 the perception of potential buyers and mortgage lenders is that properties in the protected area are at-risk from both inundation and future uncertainty. The future uncertainty with the levee being maintained, removed or reaccredited has essentially frozen the market for homes located in the protected area. This condition in the housing market constrains future in-migration of new residents into the community.

As a very small and aging community Zoar Village is particularly vulnerable to the loss of any population or change in the housing market, which in turn could significantly affect the village's financial base, municipal status, community cohesion and ultimately its success as a historic site and heritage/recreational asset.

For example, if this condition leads to a subsequent in-migration of transient occupants (renters/tenants) changes in the social and cultural makeup of the community could reduce social cohesion, participation in community events, reduced volunteerism and less participation in social organizations. Reductions in community participation could threaten the community's ability to support heritage-based tourism. A decrease in future in-migration of new homeowners who appreciate the historic value of the Village could affect the interest and ability to host festivals and garner outside financial support for maintaining the historical integrity of the community.

Zoar Village has been successful in attracting state and Federal matching funds and private foundation grants for recent work in the village. The perception by external sources of Zoar Village's long-term viability as a future tourist attraction is important to their long-term financial support and future investments. Each of the external support agencies is faced with prioritizing their funding support among competing priorities. Zoar Village has been included in those past prioritization exercises and would continue to be ranked among other resources for funding in the future. Should social, economic or environmental conditions in Zoar Village which support tourism deteriorate over time, or should there be a future catastrophic event which endangers the historic designation of the village, then external financial and administrative support could diminish as well.

The limited revenue base also constrains the community's ability to borrow funds or float bonds to support village-funded construction projects. The loss of a few residents could significantly affect the tax base which may reduce municipal services or even loss of municipal status.

This existing risk condition has led to the identification of significant societal concerns during the development of the DSMS.

Since the inception of the DSMS, Huntington District has engaged and been engaged by a large array of stakeholders, all of which have strong interest in or connections to Zoar Village. These stakeholders not only include local residents and governmental and elected officials, but regional and national level organizations including the OHC, the OHPO, Heritage Ohio, Ohio Archeological Council, the OECC, the National Trust for Historic Preservation, the National Park Service, Federally recognized Tribal Nations, and the President's Advisory Council on Historic Preservation. To date, Huntington District has received approximately 3,000 comments via email, letter, and a post-card writing campaign urging USACE to "Save Zoar, including repairing the Zoar levee and diversion dam." The NTHP, the OHC and OHPO have indicated in writing that USACE continues to undervalue the importance of this community/resource (**Appendix D – Addendum 1 – Stakeholder Comments**).

Societal concerns have also been expressed by designations. In 2012, Zoar Village was listed as one of the "11 Most Endangered Historic Places" in America due to levee performance. This annual list, compiled by the NTHP, spotlights important examples of the nation's heritage at risk. In addition to the *11 Most* designation, the NTHP named Zoar Village a National Treasure, one of only 33 such sites across the United States. National Treasures are defined as irreplaceable, critically threatened places across the country where the National Trust is making a deep organizational investment. In selecting Zoar Village for the list, the President of the NTHP, Stephanie Meeks, stated:

> *The Village of Zoar is one of those very few places in the country that transports visitors back in time, giving people an authentic glimpse of what life was like for previous generations. Working closely with the USACE, we believe a solution can be found that spares this one-of-a-kind Village from catastrophic flooding or demolition.*

To learn more about societal concerns, please visit www.savehistoriczoar.org and/or http://www.savingplaces.org/treasures/village-zoar or watch an Ohio PBS documentary which discusses the societal concerns at www.youtube.com/watch?v=w6ZLkg0grEU.

3.2.4.3. HTRW

The Phase I ESA concluded that given the age of the structures within Zoar Village, many likely contain hazardous and/or toxic materials, such as asbestos or lead paint. Other potential environmental hazards include buried heating oil tanks and electrical transformers. The Society of Separatists also operated many industrial facilities, which may have left contaminating residual material in the soil (**Figure 3-19** below). For a more comprehensive discussion of these potentials, see **Appendix D – Addendum 5**.

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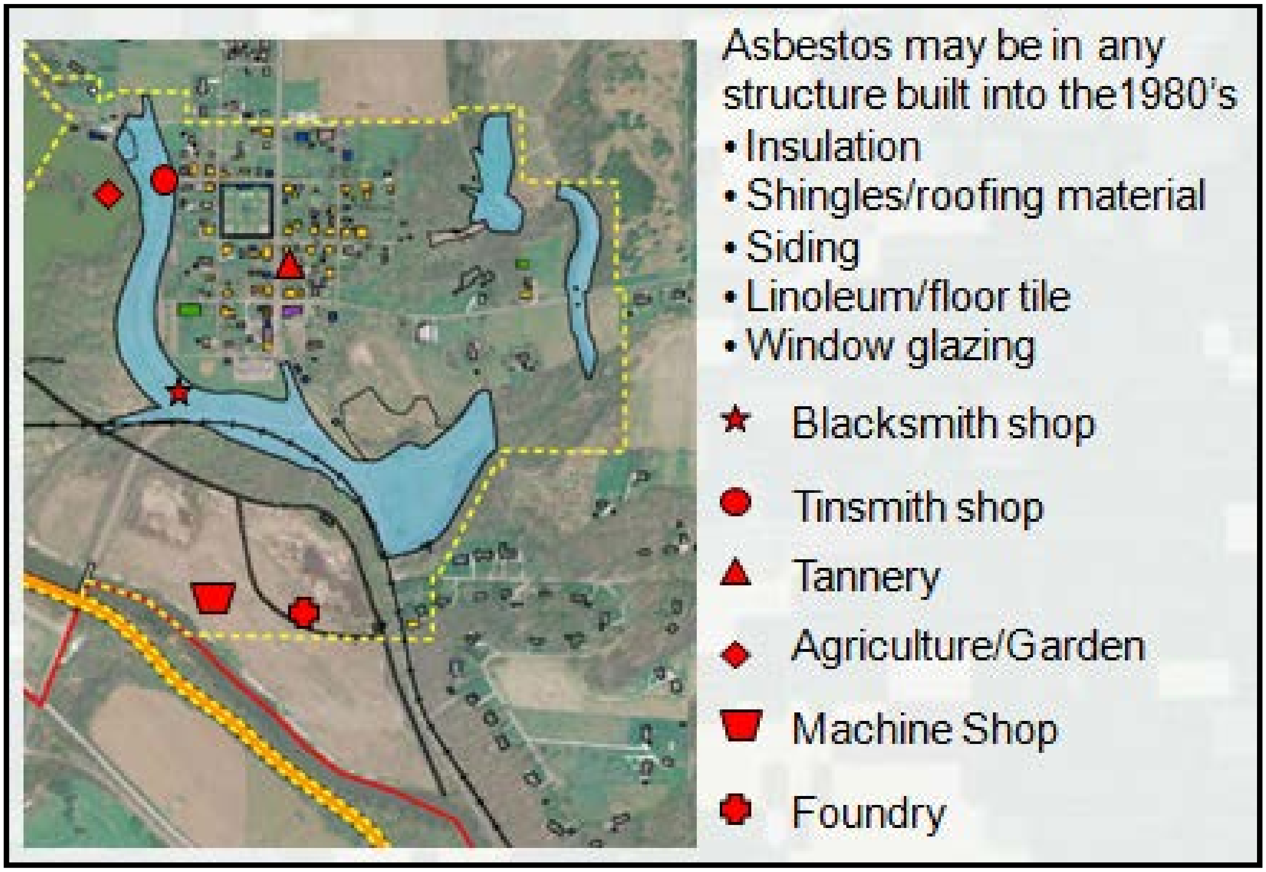

Figure 3-19 Potential asbestos locations.

3.2.4.4. Net Benefits and Flood Damages Prevented

Zoar Levee & Diversion Dam was not justified based on traditional economic benefits. The project was built to avoid having to purchase large portions of the Village due principally to its historical significance. If the levee had not been built, structures currently in the leveed area would have been removed and not subjected to flooding. Therefore, a tabulation of flood damages prevented has not been calculated or maintained for Zoar Levee.

There are approximately 57 tracts of land and 51 structures in the Village of Zoar that are within the El. 916 feet. A 2012 estimate of the fair market value of the property and buildings located behind Zoar Levee & Diversion Dam at and below El. 916 feet is $8.9 M. The total depreciated replacement cost of these buildings is estimated to be $14.9 M. The higher depreciated replacement cost reflects the higher cost of building materials required to maintain their historical integrity. Zoar Levee was raised between 1950 and 1951 to provide additional benefits to El. 925.5 feet, with three feet of freeboard, and therefore reduces the potential of economic damages to that elevation as well. The total depreciated replacement costs of all the buildings at or below El. 925.5 feet is approximately $18.5 M.

3.2.4.5. Environmental Resources

Field investigations were conducted in June 2012 to determine the location and extent of ecologically significant habitats and threatened and endangered species, and to approximate potential waters of the United States, including wetlands surrounding Zoar Levee & Diversion Dam (**Appendix D – Addendum 6**).

Eleven good quality wetlands, covering approximately 340 acres were preliminarily identified (see **Figure 3-20** below). One of these wetland areas, the Zoar Wetland and Arboretum, is very diverse and of high quality. Several of these wetlands extend beyond the study boundaries and more potential wetlands may be present within the study boundaries on properties with restricted access. With exception of the Pump Station Wetland, the majority of wetlands are located River-Side of the Levee or upstream of the Diversion Dam.

Ten streams were identified within the study area. The streams have been altered and are generally of poor to moderate quality. Artificial channels were historically excavated for canal and mill races and some more recently for agricultural drainage ditches.

No ecologically significant terrestrial habitats were located within the study area during this assessment.

The study area is within the range of the Indiana bat, *Myotis sodalis* (endangered), and the northern long-eared bat, *Myotis septentrionalis* (proposed endangered). In the winter, bats generally hibernate in caves and abandoned mines. Summer habitat requirements for the species are not well defined but the following are considered important:

- dead or live trees and snags with peeling or exfoliating bark, split tree trunk and/or branches, or cavities, which may be used as maternity roost areas;
- live trees (such as shagbark hickory and oak) which have exfoliating bark; and
- stream corridors, riparian areas, and upland woodlots which provide forage sites.

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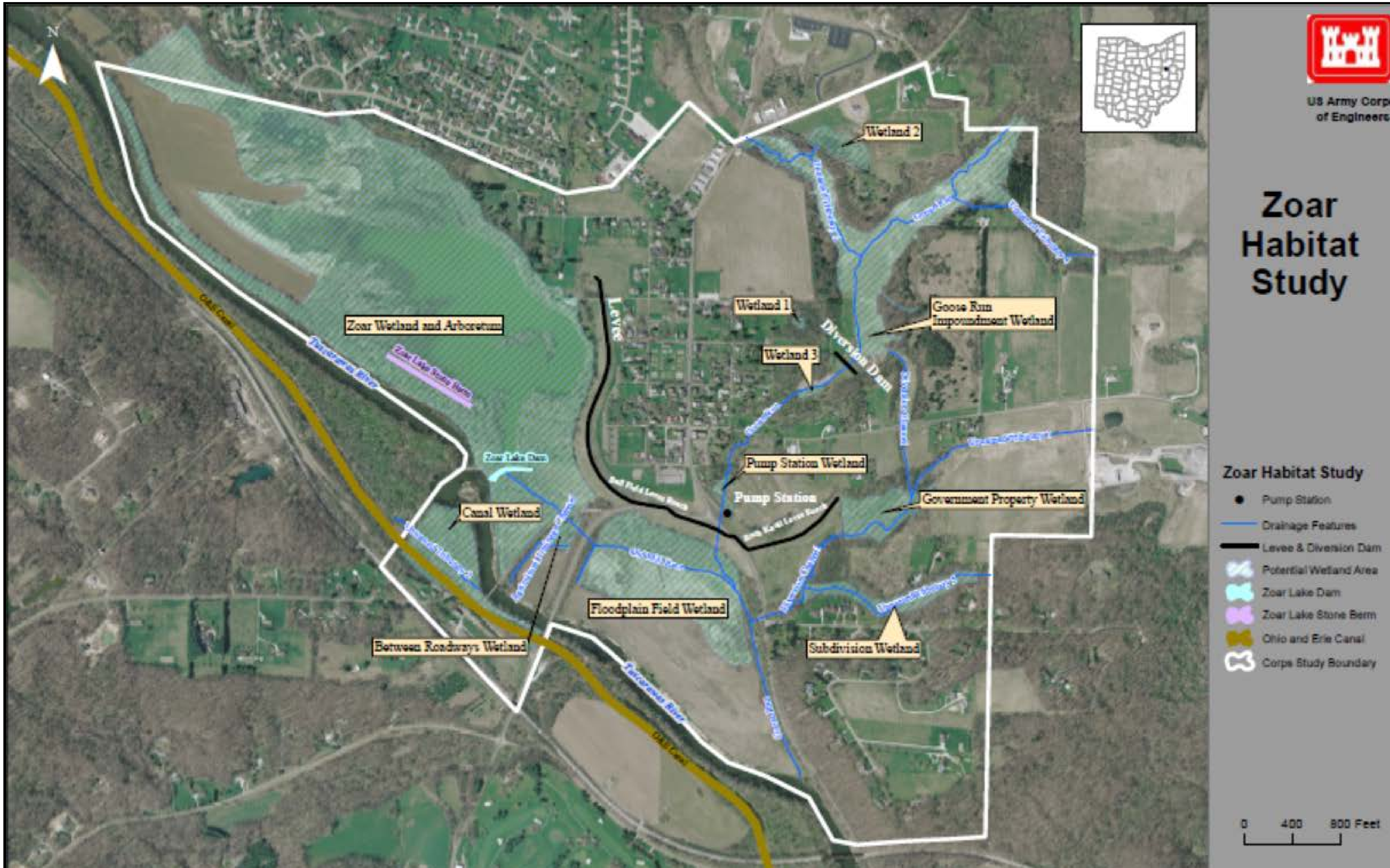

Figure 3-20 Habitat surrounding Zoar Levee & Diversion Dam. See Appendix D – Addendum 6 for more resolution.

3.3. *FWAC/NO ACTION ALTERNATIVE RISK

The following presents a description of the FWAC/No Action risk. This forecast is meant to identify the condition most likely to exist if USACE does not take action, consider what others would do absent USACE action, and provide a basis from which alternative plans are formulated and their benefits and impacts assessed.

3.3.1. Future Probabilities of Inundation Absent a Dam Safety Modification Action

Possible actions or events that could occur at some point in time which would either increase or decrease the probability of failure were considered.

For the purposes of this forecast the existing probabilities of failure presented are likely within an acceptable range of variability discussed for the next 50 years. In terms of inundation probability from a breach, as it relates to the Ball Field/Rock Knoll Reaches and the diversion dam, repeated loadings could increase risks if progression toward failure was initiated during one or more of these loadings. However, the annual probability of these loadings must also be considered. For example the pool of record for Dover Dam is El. 907.4 feet (1 in 45 chances of recurrence each year). Therefore, statistically speaking, this event has a low probability of occurring repeatedly over a 50 year period. It is possible that component deterioration may also increase failure probabilities over time but this forecast assumes the project shall be properly operated and maintained, as discussed in **Section 3.3.2.1**. As discussed in **Section 3.3.2.6**, it is unlikely any other agency or organization would take action to lower incremental risks associated with breaching.

This forecast does assume the probability of a pump failure leading to inundation could be lowered below USACE Tolerable Risk Guidelines by actions explained in **Section 3.3.2.2**. Uncertainties with this assumption are also acknowledged.

The probabilities of overtopping are also likely to stay within an acceptable range of variability for the next 50 years. While overtopping would be unlikely to lead to a breach, it will continue to be the highest risk of inundation to Zoar Village. The principle factors which contribute to overtopping probabilities include the presence of Dover Dam, upstream development and precipitation models. Given recent investments made in Dover Dam, it is reasonable to assume it will continue to operate as intended over the next 50 years. As will be discussed in **Chapter 4.0**, there are three other Federally owned and operated upstream flood risk management dams which contribute to Dover Dam's impoundment area. It is reasonable to assume they will continue to be operated. The majority of the Tuscarawas River upstream of the project is uncontrolled and future development may occur, which could increase run-off and river stages. However, many of the areas are currently developing Watershed Management Plans and working to manage issues like stormwater runoff. The MWCD recently enacted a watershed assessment which is designed to collect fees to help address issues associated with impervious surfaces.

Perhaps the biggest unknown is how climate change could affect future risks. As discussed in **Section 1.7** an ongoing Ohio River Basin Climate Pilot Study indicates, for the Muskingum Basin, the possibility of a slight increase in discharge of 15 percent during the later years of the period of analysis (2014-2064). For more information on this study, see **Appendix D – Addendum 7**. This forecast is based upon data gathered at McConnellsville, Ohio (near the mouth of the Muskingum River) and may not accurately represent what would happen along the Tuscarawas River at or near Zoar Levee. However, based upon available data, and considering uncertainty, it assumed that climate change may not have a significant effect on future inundation risks.

Based on this understanding, it is estimated there is an approximate 2.1 percent chance of inundation over the next 50 years (0.04 percent chance every year) due to breaching, over-topping or pump station failure without a breach. The risk of inundation is approximately 1.3 percent over the next 50 years (0.03 percent chance every year) without considering overtopping. These estimates do not take into account the effects of intervention. They do include the assumption that pump failure inundation risks would be lowered to be below USACE Tolerable Risk Guidelines (see **Section 3.3.2.2** below).

3.3.2. Future Assumptions Absent a Dam Safety Modification Action

The following lays out key assumptions used to forecast risk into the future, including the probabilities provided above. Estimates of risk in the future also require a forecast of the health of the leveed area over the next 50 years. To do this, key assumptions about drivers to the future health of Zoar Village are discussed. As risk includes an understanding of consequences, knowing what may happen to Zoar Village over the next 50 years is important.

3.3.2.1. Future Standard Operation and Maintenance Activities

The continued operation and maintenance of Zoar Levee & Diversion Dam is required for Zoar Village to continue to exist and provide public benefits. Absent a Dam Safety Modification, breach or other significant inundation, it is reasonable to assume the Federal government will continue to own and USACE will continue to operate and maintain Zoar Levee & Diversion Dam. The total annual cost of operating and maintaining the levee and diversion dam is estimated to be $49,380, including labor, utility, mowing and vegetation control (**Table 3-1**).

It is also reasonable that costs associated with fixing/replacing failing or failed equipment, such as gates and their operating equipment, and pumps and their associated electrical/mechanical equipment, would be accomplished, as required, over the next 50 years. It is likely over the next 50 years, approximately $742,400 would be spent fixing electrical/mechanical equipment, with the most likely candidates for repair or replacements listed below in **Table 3-1**. It is also reasonable to assume USACE would maintain relief wells over the next 50 years at a total cost of over $1 M.

Table 3-1 Standard operation and maintenance costs for the next 50 years.

Component	Cost
Labor, utilities, mowing/vegetations	$2,469,000 (= $49,380 x 50 years)
Levee & diversion dam gates	$20,000
Diversion dam electric gate operator	$7,000
Submerged electric gate operator	$7,000
Replacement of generator	$450,000
New motor control center	$75,000
Repair of pump discharge pipes	$180,400
Pump floats (mercury switches)	$10,000
Relief well maintenance	$1,088,250
Total cost	**$4,305,650**

3.3.2.2. Future Maintenance Actions to Reduce Pump Inundation Probabilities

It is reasonable to assume relatively low cost maintenance activities can be accomplished absent a Dam Safety Modification which could reduce the annual probability of pump failure.

Upgrades to the diversion channel would be accomplished in conjunction with the changes to operation of the diversion dam gate to mitigate the risks associated with increased hydrologic loading and overtopping. A flow constriction is created by a 5-foot circular metal pipe at the Second Street crossing of the diversion channel. This constriction would be eliminated by replacing the existing pipe, which is deteriorated, with a larger conduit. Preliminary cost estimates suggest this upgrade could be accomplished for approximately $390,000 (Fiscal Year 2014 dollars).

Even with diversion channel work, the change in risk of pump inundation is still above the USACE TRLL for annual probability of failure. This is principally due to the age of the two oldest pumps, which have an estimated 8.4 percent chance of failure every time they are operated.

To mitigate for these risks; it is also assumed that in addition to the component maintenance described in **Section 3.3.2.1**, the two oldest pumps would be rehabilitated at an estimated cost of $360,000 (Fiscal Year 2014 dollars).

When combined, replacement of the diversion channel culvert and the pump rehabilitation are estimated to reduce interior pump inundation risks below the USACE TRLL for annual probability of failure (see **Figure 3-21** below). The total cost for these activities is $750,000 (Fiscal Year 2014 dollars).

These activities are forecasted to be completed sometime over the next 50 years, as they fall well below the threshold for major maintenance ($6 M). However, it is possible they may not be accomplished in the near-term, or that constrained operations and maintenance funding could limit the ability to achieve all these action items. The ability to fund the removal of the diversion channel constriction and rehabilitate the pumps creates the uncertainty in the forecast of the FWAC/No Action risk.

It is extremely important to note that if these activities are not accomplished, inundation risks to Zoar Village due to pump inundation would remain above the USACE TRLL for annual probability of failure and could counteract any investment made to reduce incremental risk associated with breaching.

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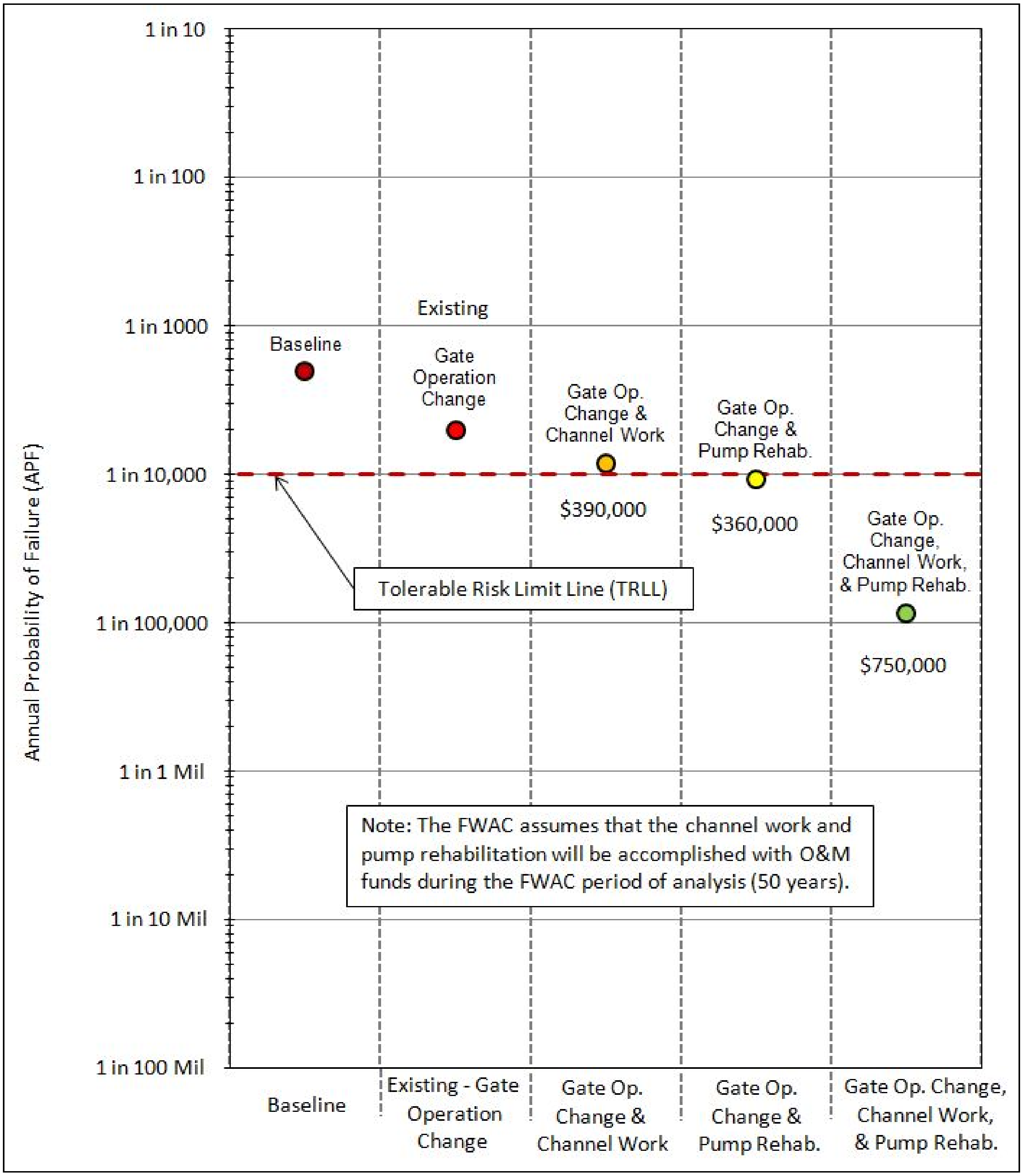

Figure 3-21 FWAC/No Action annual probability of pump failure.

3.3.2.3. Future Major Maintenance or Rehabilitation Activities to Reduce Inundation Probabilities

It is unlikely that USACE could accomplish a major maintenance (exceeds $6 M) or major rehabilitation action which could reduce inundation probabilities. Major maintenance is not anticipated given the associated costs. Zoar Levee & Diversion Dam is also unlikely to qualify for Major Rehabilitation, as these efforts are generally reserved for navigation projects or projects with significant economic benefits. See **Appendix A – Volume II** for a more detailed rationale behind this conclusion.

3.3.2.4. Future Flood-Fighting Activities

Given past performance issues, it is also reasonable to assume costs may be incurred over the next 50 years associated with flood-fighting. It is reasonable to assume USACE would continue to take emergency actions in the future to intervene against potential inundation risks. Two types of flood fighting costs were considered and are described below:

1) Standard impacts are those incurred by routine flood fighting activities associated with surveillance and minor actions which can be handled by government personnel both during and following a flood event. These costs are multiplied by the annual chance of loading to annualize the potential costs over a 50 year period (see **Table 3.2** below).

2) Major impacts are those activities which exceed routine flood fighting and often require the execution of a contract either during the event or following. Installation of the 2008 Emergency Blanket is an example of a major impact. These costs are multiplied by the annual chance of loading and then again by the probability of poor performance (**Table 3-2**).

Table 3-2 Standard & Major Impact Costs For Next 50 Years

Component	Impacts	Annualized Cost
Levee	Standard	$26,175
Levee	Major	$4,324
Diversion Dam	Standard	$15,030
Diversion Dam	Major	$3,714

It is also reasonable to assume Huntington District would continue to enact surveillance plans over the next 50 years for Zoar Levee & Diversion Dam. Actual actions are not prescribed and a full array of activities, including taking emergency actions or recommending evacuation of the population at risk, would have to be considered at the time of the event. The costs associated with standard and major impacts account for surveillance activities.

3.3.2.5. Future Levee Accreditation

Accreditation of Zoar Levee to withstand the base flood event is a key factor in determining the future viability of Zoar Village. As discussed in **Section 3.2.4.2**, the lack of accreditation has significantly affected many of Zoar Village's vulnerabilities and could lead to a significant degradation in the health of the community, its historical integrity and its heritage tourism.

While annual probabilities of failure above USACE TRLL have been identified, the results of the existing condition risk indicate a reasonable confidence in Zoar Levee's ability to withstand a base flood event.

Given the levee's height of El. 928.5 feet and the approximate elevation of the base flood event (El. 912.5 feet) there is a high degree of confidence that Zoar Levee would not be overtopped by this event. Furthermore, hydrologic analysis and system response probabilities for breaching of the levee or inundation of the pump station during a Dover Dam impoundment, indicate that there is a reasonable assurance that Zoar Levee would withstand a base flood event. Therefore, after completing a thorough risk based analysis, USACE has reasonable confidence that Zoar Levee can reliably withstand the base flood event. At the request of Zoar Village, and on their behalf, USACE has utilized this information to provide FEMA a positive LSE for the base flood event. Zoar Village is using this positive LSE to request that FEMA revise the Flood Insurance Rate Map (FIRM). While it is up to FEMA to make an accreditation determination in accordance with the NFIP regulations, for the purposes of this forecast it is assumed FEMA will ultimately re-accredit the levee and update the FIRM accordingly.

3.3.2.6. Non-USACE Risk Management Actions

Absent a Dam Safety Modification, reasonable actions agencies or other organizations may take to manage inundation risks must also be considered.

As discussed above, it is assumed that Zoar Levee will be re-accredited by FEMA to withstand the base flood event in the near term.

It is not anticipated other agencies, such as Tuscarawas County Homeland Security and Emergency Management Agency (TCHS & EMA), Ohio Emergency Management Agency (OEMA), or FEMA would take additional actions, such as implementation of a hazard grant mitigation program. FEMA's Hazard Grant Mitigation Program (HGMP) is designed to assist flood prone areas located within the floodway or floodplain for the base flood event. Once Zoar Levee is re-accredited, Zoar Village is unlikely to qualify for these programs as it will no longer be considered to have the same risk.

It is assumed that TCHS & EMA will maintain and update its Emergency Evacuation Plans for Dover Dam; which include plans for Zoar Village.

3.3.2.7. *Future of Zoar Village Absent a Dam Safety Modification Study

In summary, it is assumed that over the next 50 years:

- USACE is likely to operate and maintain Zoar Levee & Diversion Dam, including executing approximately $750,000 worth of upgrades to reduce pump inundation annual probability below the USACE TRLL;
- USACE is unlikely to implement any major maintenance or rehabilitation work to reduce annual breach probabilities, which would remain above the USACE TRLL;
- USACE is likely to continue surveillance and flood-fighting as required;
- USACE is likely to provide a positive LSE that Zoar Levee can withstand the base flood event with reasonable assurance;
- FEMA is likely to accredit Zoar Levee; and
- No other agency or organization is likely to implement any further risk management actions at Zoar Village.

With this understanding, and absent a breach, pump inundation, or overtopping, Zoar Levee & Diversion Dam should continue to accrue social, recreational and cultural/historical benefits associated with Zoar Village. Key to this assumption is that re-accreditation of the levee should alleviate many of the adverse effects the existing condition is having on Zoar Village's vulnerabilities. For example, the lack of accreditation and the stigma that has significantly impacted susceptible vulnerabilities (such as the housing market), if not resolved, would create a domino effect, impacting the continued sustainability of Zoar Village.

Although levee accreditation does not reduce annual probabilities of breach or guarantee that Zoar Levee will not experience performance issues, or that flooding cannot or will not occur, Zoar Village has shown in the distant and more recent past that it can continue to overcome inundation risks of this magnitude as long as: the levee is accredited against the base flood event, USACE is committed to continuing to operate and maintain the project, and flood-fight when required.

It is unlikely that the leveed area within Zoar Village shall grow substantially over the next 50 years. The village has maintained a near-static population of around 150-200 people since its establishment in 1817. Further, as the 2010 Comprehensive Plan developed for Zoar Village indicates, restricting new development within the leveed area is important to the village's continued success as a historic site. This historic site would lose its integrity and appeal with such development. This is recognized by Zoar Village and its stakeholders and they actively work to preserve the "historical" atmosphere of the village.

3.3.2.8. *Future of Environmental Resources

Little change would be expected for aquatic and terrestrial habitat as most of this is found in flowage easements for Dover Dam and/or the Zoar Diversion Dam, which restrict development. Much of this habitat has developed as a result of this protection. As it is forecasted that both of these flood risk management features will remain in place over the next 50 years, the habitat created by their flowage easements should continue. There may be increased recreational traffic, as the Ohio & Erie Canal Towpath trail and Zoar Lake may attract more visitors; but as these features are focused on eco-tourism, it is likely they would not have negative impacts to the environmental resources they are nested within.

3.4. CONSEQUENCES OF A BREACH OR PUMP INUNDATION

To build upon the understanding of what the existing and future risks for Zoar Village are, the following discussion forecasts the consequences if the levee were to breach or the pumps become inundated. The consequences of such events to life, the societal value of Zoar Village, and economic damage are detailed below. Given the discussion in **Section 3.3.2.7**, the consequences are not estimated to change drastically between the existing condition and FWAC/No Action. While overtopping is not specifically discussed, because it is non-breach risk, the consequences would be similar as those discussed below.

3.4.1. Potential for Loss of Life from a Breach or Pump Inundation

The surveillance plans for Zoar Levee & Diversion Dam require daily inspections and 24-hour surveillance at elevations above 905 feet for the levee and 906 feet at the diversion dam. The estimated long breach-formation times, combined with the full time surveillance, results in a very high likelihood of identifying a breach. Warning signs of a breach would likely start days in advance of a full breach. This would provide some time for emergency intervention measures and time to identify when intervention efforts would be unsuccessful and an evacuation should be recommended.

Inundation from a pump failure may occur with little warning if the two oldest pumps were to fail. However, this lack of warning time should be offset by the short distance to high ground discussed below.

During significant storm events Huntington District remains in contact with the TCHS & EMA. The Tuscarawas County response to a possible project breach is guided by the Tuscarawas County Emergency Evacuation Plan for Dover Dam, prepared by the county in 2007 (available at http://www.co.tuscarawas.oh.us).

Figure 3-22 below shows the population distribution by census block in and around Zoar Village, along with the structure points evaluated for damages. The resident data by census block shows that the majority of the population at risk resides to the north and east of town where ground elevations are higher, putting them at lower risk, should the levee breach or pumps fail when the Dover pool is at lower elevations. Structures higher in elevation are also closer to the inundation boundary, meaning they are a short distance away from areas considered to be safe. This provides justification to assumptions that time needed to successfully evacuate the population at risk is short.

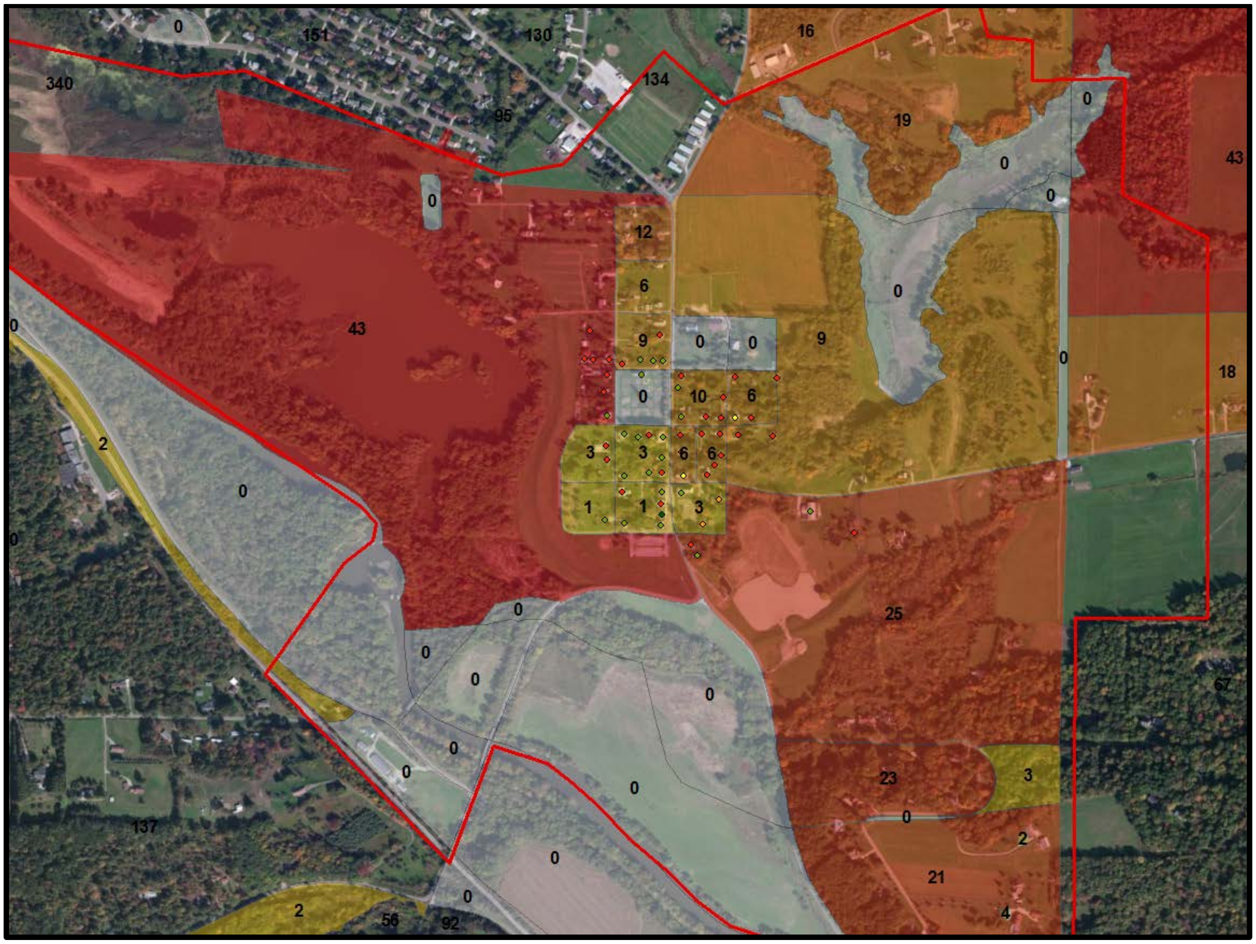

Figure 3-22 Population distribution by census block.

Zoar Village has a volunteer fire department on the north side of town, uphill from the inundation area behind the levee. The fire department itself would not be at risk of flooding, meaning it and the Zoar Church could both be available as safe locations for evacuees. During the March 2008 Event, the fire department was used as a staging area for USACE employees and emergency service workers who contacted area residents. The village population has significant knowledge about the risk involved with the levee, particularly after flood events in 2005 and 2008. There have also been numerous public meetings in the village to keep them apprised of risk reduction efforts. These factors, combined with the small geographic area in consideration, increase the likelihood that an evacuation warning would disseminate quickly throughout the village and be taken seriously by residents.

There are other factors which may influence the number of population at risk during a significant storm event. During flood control operations by both Dover and Bolivar Dams many of the roads surrounding Zoar Village are inundated. For example, in the January 2005 Event, the ramps to the Bolivar Interstate Exchange were inundated, and Rt. 212 is well below Dover

Dam's impoundment. As a result people who decided to leave the area were evacuated by boat and later helicopter.

Inundated roads would limit egress and ingress during higher pools, which could complicate evacuation. However, access to high ground by foot from those portions of Zoar Village within the leveed area would not be restricted by inundated roads. In addition, Tuscarawas County has an Emergency Evacuation Plan for Dover Dam that recognizes these road inundations and provides for emergency routes and communications plans. Large storm events and the resulting road inundation could be a factor in reducing the number of people in Zoar Village during higher pool events regardless of project performance. For example, tourism is unlikely to be a factor due to area flooding and perhaps timing as well. Traditional impoundments behind Dover Dam have historically occurred during the "off-season" for festivals and tours, which reduces the exposure probability to tourists. At high pool occurrences, single day visitors may not be in the area due to the flooding but would likely be the first to evacuate in the case of any voluntary evacuation recommendation. For these reasons, tourism visitation was not considered as a significant impact to population at risk or life loss.

Once an evacuation warning is issued, the town would need to mobilize to a safe location. While the distance to high ground is not very far (maximum of 1/3 of a mile), mobilization of some villagers may take more time than average due to the factor of age. Twenty-six percent of the population of Zoar Village is over 65 years old, and the median age in the village is eleven years higher than that of Tuscarawas County. Elderly residents may need some assistance to mobilize for an evacuation, meaning that more time could be required. The fact that most households have privately-owned vehicles and higher education levels than county and state averages may offset the increased mobilization time required for elderly residents. Also, Zoar Village is a close knit community, and residents and fire rescue workers generally know which residents would need assistance during a flood evacuation. It is reasonable to assume there would be ample time for these evacuations, even for individuals requiring assistance.

For these reasons, the estimated loss of life from a breach of Zoar Levee or Diversion Dam was approximately one person in the most likely scenario. When annualized, this estimate falls within the USACE Tolerable Risk Guidelines for incremental life loss consequences. Even if the pumps failed while Dover Dam was impounding significant water on the outside of the levee, the loss of life consequences are anticipated to be lower than in the case of a breach of the levee, as the rate of rise of water would be much slower allowing for additional warning time to evacuate the population at risk. The life loss estimate was developed by the cadre and informed by results of a HEC-FIA analysis, details of which can be found in **Appendix A – Volume 1**.

As loss of life falls within the USACE Tolerable Risk Guidelines, the focus of this report shall be on annual probabilities of failure, and therefore traditional f-N charts are not provided.

3.4.2. Potential Consequences to Zoar Village's Societal Value from Breach or Pump Inundation

If Zoar Levee were to breach and water from Dover Dam's impoundment were to inundate those portions of Zoar Village within the leveed area, or if Zoar Diversion Dam were to breach and water from the Goose Run impoundment were to inundate those portions of the village located downstream, the consequences to the community, its historical integrity and recreational benefits could be severe.

Even if velocity of flow was not sufficient to cause structural damage to the buildings, it is likely standing water could be present for a number of days if not weeks, especially in the case of a high Dover Dam impoundment. If a breach was repaired, it would likely take some time to pump all the water out of the village. If a breach was not repaired, or if pumps failed, it may also take some time before Dover Dam's or Goose Run's impoundment receded and residual water could be pumped out of the village. This duration would likely lead to structural rot, increase in mold, and lost possessions. In addition, flood waters often carry with them potentially harmful contaminants which can pollute building materials and surrounding soils making them hard to clean for reoccupation. Long-term inundation often leads to sedimentation that can infiltrate buildings and potentially cause harm. Removal of sedimentation can also require damaging activities to the integrity of buildings.

Water and sewer systems would also have to be pumped out and sanitized. Mechanical and electrical infrastructure located below the inundation elevation is likely to be destroyed, including home heating and air conditioning units. Depending on the velocity of flow or the location of the breach, other infrastructure such as roads in the village or on top of the levee could be damaged.

Building contents would have to be removed, sanitized or otherwise replaced, especially in public facilities, such as restaurants. Portions of buildings that are submerged are typically stripped down to load-bearing members and pressure washed. This is done principally to ventilate the structure to help it dry and reduce mold penetration, as well as remove any contaminants. However, the sturdy construction materials utilized for some of the 19th century buildings in Zoar Village (masonry, timber-framed, and log homes) may be able to withstand inundation in ways modern balloon-framed buildings cannot.

For example, the weight of masonry buildings or timber-framed buildings with brick and stone chinking may keep them from becoming buoyant, but fast rising water may still cause structural damage. Log homes might be particularly susceptible to buoyancy. Any buildings that do become buoyant, in addition to other floating debris, could cause damage to other buildings.

Following a breach, a decision to re-establish the project would have to be made to allow for restoration of the community. Based upon the vulnerabilities discussed in **Section 3.2.4.2**, it seems unlikely the project would be rebuilt as most of its benefits would have been damaged beyond reasonable repair.

Following a pump failure, a decision to repair the pumps would have to be made to allow for restoration of the community. This decision could likely depend on the circumstances surrounding a pump station failure. For discussion purposes, it is assumed if water on the interior reached or exceeded El. 900 feet this decision could be complicated. This elevation was chosen as a pivot point, because 19 structures are affected and an excess of $1.1 M of damage is estimated to have occurred (see **Figure 3-23** below). Given the small size of the community, this level of impact would be a significant issue. **It is noteworthy that El. 900 feet is only 4 feet higher than El. 896 feet, the elevation in which the pumps become inundated and no longer operable**. Unless rising water would crest at or near this elevation, it is likely that the rate at which water was rising would increase significantly once the pumps became inundated.

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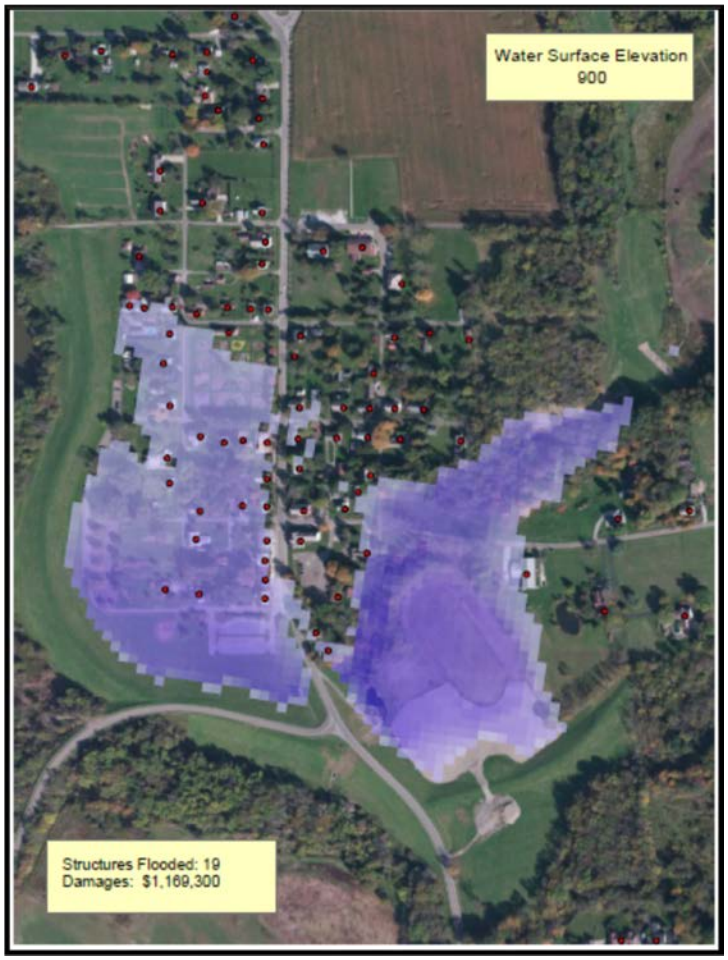

Figure 3-23 Extent of water at El. 900.

Zoar Village's success as a functional community is tied to its historical identity and tourism industry. Without additional investments geared to restoring the historical integrity of the community, it is unlikely that Zoar Village would remain viable. Efforts to clean up and refurbish buildings and the surrounding landscape while maintaining the historic integrity of Zoar Village would add to the cost and complications associated with doing so.

In consultation with the USACE Technical Center for Expertise for the Preservation of Historic Buildings, additional efforts would be required following inundation to reestablish the community's historic character. See **Appendix A – Volume II** for more information.

Restoring the historic integrity of damaged buildings would likely require investment not only from building owners, but the OHC and State of Ohio or other interest groups, especially if a State Memorial Site was to be retained at this location.

Further, is likely that following inundation due to a breach or pump failure, Zoar Village would likely lose residents. Given these considerations and challenges, it seems plausible that following a breach of the project or a significant inundation due to pump failure, Zoar Village, at least those portions significantly inundated, would not be able to feasibly reestablish. Given its small size, Zoar Village as a municipality would cease to exist if most of the community was damaged and chose not to reestablish. This would result in the loss of a nationally significant historical site and valued recreational site.

3.4.3. Potential Economic Consequences from Breach or Pump Inundation

Economic consequences would again be a function of the magnitude of the event. **Table 3-3** below plots the economic consequences associated with various elevations of water on the inside of the levee. At El. 900 feet, economic damages exceed $1.1 M and affect approximately 19 structures. At El. 915 feet, economic damages are in excess of $14 M and 53 structures are affected. These damages were estimated using the HEC-FIA software; details of the analysis can be found in **Appendix A – Volume I**.

Table 3-3 Estimated economic damages (Fiscal Year 2012 price level)

Project Component	Pool Elevation (feet)	Total Direct Damages
Levee	900	$1,061,000
	904	$4,670,000
	907	$7,389,000
	916	$16,606,000
	925	$21,293,000
	928	$23,221,000
	930 - overtopping breach	$23,518,000
	935 - overtopping breach	$24,779,000
	930 – overtopping, no breach	$23,518,000
	935 – overtopping, no breach	$24,779,000
Diversion Dam	904.5	$148,000
	916	$1,295,000
	922	$5,030,000
	928	$7,300,000
	932	$14,369,000

3.5. SUMMARY OF EXISTING AND FUTURE RISKS

In summary, existing and future risks indicate that Zoar Levee presents an annual probability of inundation from breaching or pump inundation that is greater than the USACE TRLL of 1 in 10,000 chances every year. The Zoar Diversion Dam also has incremental inundation probabilities, but these are estimated to be well below the USACE TRLL. These estimates of probabilities do have significant uncertainties associated with the nature of the geology.

While estimates of life loss from resulting inundations are low given a number of factors, there is the potential for loss of life if a breach or pump inundation were to occur. However, risk estimates indicate that the FWAC/No Action Alternative would achieve the USACE tolerable risk limit for life safety only. Another consequence of resulting inundations would be to the demonstrated societal value Zoar Village provides as a community, regionally important heritage tourism asset and nationally significant historical site. It is forecasted Zoar Village would likely continue to maintain a viable community, heritage asset and historical site into the future as long as Zoar Levee & Diversion Dam is operated and maintained and the levee is re-accredited to withstand the base flood event in the near-term.

The FWAC/No Action scenario assumes the probability of failure from pump inundation can be lowered below the TRLL through the execution of maintenance packages to rehabilitate the two oldest pumps and replace a restriction at the diversion channel. There is uncertainty associated with receiving sufficient funding to accomplish all these activities.

Two PFM's (PFM 1A-2 & PFM 1A-4) at Zoar Levee are forecasted to continue to present annual probabilities of breach that are greater than the USACE TRLL of 1 in 10,000. Therefore, the moderately high probabilities of breach at Zoar Levee, when combined with the potential consequences to a unique and valued resource from a breach, warrant Federal action to manage identified incremental risks that are not acceptable under USACE Tolerable Risk Guidelines.

Overtopping of the levee does and will continue to present the greatest probability (1 in 6,000 chance every year) of inundation to the leveed area. While the consequences of overtopping would be similar from a breach or pump failure, overtopping is not estimated to result in a breach. Therefore, addressing overtopping is beyond the purpose and need for Federal action.

With this understanding, the next step was to formulate alternatives to reduce and manage the incremental risks outside the USACE Tolerable Risk Guidelines. The focus of alternative formulation was to address PFM 1A-2 & PFM 1A-4.

4.0 FORMULATION OF ALTERNATIVES

The following chapter summarizes how a final array of alternative risk management plans was developed to meet the purpose and need; managing the incremental risks which do not meet USACE Tolerable Risk Guidelines.

As discussed in **Chapter 3.0**, no actionable PFMs were identified for the diversion dam and the FWAC/No Action forecasts that pump failure probabilities can be lowered to meet USACE Tolerable Risk Guidelines through maintenance packages that should cost an estimated $750,000 (Fiscal Year 2014).

Therefore, formulation of risk management plans focused on the two specific failure modes found to drive incremental risk and warrant Federal action; PFM 1A-2 and PFM 1A-4. To address these PFMs risk management measures were brainstormed. Measures are ways to address the risks that can stand alone or be combined into one or more alternatives. Generally, measures were broken into two categories:

- Structural Measures are ways to address risks by structurally modifying the levee;
- Non-Structural Measures are ways to address risks without structurally modifying the levee.

An initial array of risk management measures were then screened against the purpose and need; keeping in mind the dam safety issues, opportunities, objectives and constraints. Remaining measures were then combined into an initial array of alternative risk management plans. An initial array of alternative risk management plans were then screened using the same process for measures screening, until a final array of reasonable alternative plans was developed.

As required by ER-1110-2-1156, a Value Engineering study was performed during the measure screening process. The Value Engineering report can be found in **Appendix I**.

Risk management plans were formulated to achieve tolerable risk considerations defined in ER 1110-2-1156; called As Low As Reasonably Practicable (ALARP Considerations). In summary, ALARP Considerations require the incremental costs to lower risks below USACE Tolerable Risk Guidelines be considered when deciding what is a reasonable investment.

4.1. Measures Screening

Table 4-1 below lists all of the screened out risk management measures. For a more detailed discussion of each screened out measure, see **Appendix M**. A brief discussion of the measures carried forward into formulation follows.

Table 4-1 List of Risk Management Measures Screened Out from Further Consideration

Measure	Status	Reasoning
Remove the Project	*Screened Out*	expensive $40-50 M, impactful, creates societal concerns
Reduce Levee Height	*Screened Out*	fails the "do no harm" principle by transferring risk
Increase Upstream Storage	*Screened Out*	expensive and impactful (~2700 acres and 300 structures impacted)
Relocate or Divert Tuscarawas River	*Screened Out*	does not address purpose and need
Remove Dover Dam	*Screened Out*	fails the "do no harm" principle by transferring risk
Increase Dover Dam Releases	*Screened Out*	fails the "do no harm" principle by transferring risk
Relocate Population (Life-Safety)	*Screened Out*	life-safety already below the TRLL; expensive and impactful
FWEEPS (Life-Safety)	*Screened Out*	duplicative to existing evacuation plans
Actions from Others	*Screened Out*	no other agency with authority to take action
Replace Levee	*Screened Out*	does not address purpose and need
Seepage Cut-Off Wall	*Screened Out*	expensive ($40-100 M)
Chemical Grouting of Pervious Foundation	*Screened Out*	more expensive than cut-off and less reliable
Upstream Impervious Blanket	*Screened Out*	expensive and impactful (~65 acres purchase; mitigation for wetland impacts)
Pumped Well Points at Ponding Area	*Screened Out*	less cost-effective than relief wells
Expand Ponding area	*Screened Out*	additional cost; little risk reduction benefit

4.1.1. Village-Side Weighted Filter Berm (Carried Forward)

Consideration was given to construction of one or more weighted filter berms on the Village-Side of the levee. A weighted filter berm is usually an earthen berm of various thickness and widths, placed on the ground surface landward of the levee to resist heave, and/or filter any materials eroding out. As a proven measure implemented in similar environments, **this measure was carried forward to be developed into one or more alternatives**.

4.1.2. Relief Wells (Carried Forward)

Consideration was given to additional relief wells to reduce water pressure in the ground that contributes to PFM 1A-2 and PFM 1A-4. Relief wells are cylindrical wells (10-12 inches in diameter) driven vertically below the ground to draw surrounding water up into the well. The attracted water can then exit on the ground surface or be directed to a collector pipe which outlets the collected water to a desirable location. For Zoar Levee & Diversion Dam, a collector pipe exiting at the ponding area for the pump station would be considered to avoid impacting nearby buildings. As a proven measure implemented in similar environments, **this measure was carried forward to be developed into one or more alternatives**.

4.1.3. Village-Side Toe Drain (Carried Forward)

Consideration was given to a toe drain designed to reduce water pressures that contribute to PFM 1A-2. A toe drain is a sand and gravel filled trench excavated below the ground on the Village-Side of the levee designed to attract and collect water. For Zoar Levee & Diversion Dam, the toe drain would be designed to pipe water to the ponding area. As a proven measure implemented in similar environments, **this measure was carried forward to be developed into one or more alternatives**.

4.1.4. Internal Erosion Interception Trench (IEIT) (Carried Forward)

Consideration of designing a vertical filter that would effectively cut-off or arrest any backward erosion piping which initiated Village-Side of the levee was given. The measure would consist of a trench excavated to a depth of no less than five feet below the confining layer into the underlying sands and gravels. The trench would then be backfilled with material that would resist eroding and arrest any backward erosion piping which has started. This measure differs from the Toe Drain, as it would not be designed to collect or drain any seepage.

This idea was developed when risk estimates credited the collector trench installed in 2009 with the potential to arrest any backward erosion piping that might occur. However, as this collector trench was limited in length and depth and not designed for this function, further consideration of this type of project feature was warranted and **this measure was carried forward to be developed into one or more alternatives**.

4.1.5. Sheet Pile Interceptor at Ponding Area (Carried Forward)

Consideration was given to driving metal sheet piles between the levee toe and ponding area to intercept and potentially arrest any backward erosion piping that may have initiated. This measure was identified as an alternative to installing an IEIT at the ponding area. The need to consider an alternative to an IEIT was necessary given the space constraints created by the proximity of the levee, the ponding area, gravity pipes and pump station infrastructure. Therefore, t**his measure was carried forward to be developed into one or more alternatives**.

4.1.6. Filter Improvement at Ponding Area (Carried Forward)

Consideration was given to dredging the existing sediment within the ponding area and then replacing it with gravels designed to filter and prevent erosion of underlying soils. This filter would then be armored with stone large enough to allow for periodic dredging of the ponding area without damaging the underlying filter. A potentially reasonable option, **this measure was carried forward to be developed into one or more alternatives**.

4.2. Alternative Screening

The remaining measures were then assessed to see which could stand alone and which could be combined into other alternatives. This resulted in an initial array of alternatives (**Table 4-2**). Refer to **Appendix I** for a full description of the engineering analysis behind the initial array of alternatives.

Each alternative included options designed to reduce risks from PFM 1A-2 along the Ball Field Reach, and options to reduce risks from PFM 1A-4 in the ponding area. In summary, 10 different possible options were identified to address risks from PFM 1A-2 and labeled Ball Field Options 1-10. Four different possible options were identified to address risks from PFM 1A-4 and labeled Ponding Area Options A-D.

When combined, a total of 40 alternatives were formulated (1A-10D) (see **Table 4-2** below). This list was evaluated again to see if any could be screened out prior to advancing them for evaluation and comparison.

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Table 4-2 Initial Array of Alternatives

Alternative	Ball Field (PFM 1A-2) Options	Ponding Area	Status
1A	Weighted Filter Berm	Filter	Screened
1B	Weighted Filter Berm	Relief Wells	Screened
1C	Weighted Filter Berm	IEIT	Screened
1D	Weighted Filter Berm	Sheet Wall	Screened
2A	Toe Drain	Filter	Screened
2B	Toe Drain	Relief Wells	Screened
2C	Toe Drain	IEIT	Screened
2D	Toe Drain	Sheet Wall	Screened
3A	**Relief Wells**	**Filter**	**Advanced**
3B	Relief Wells	Relief Wells	Screened
3C	Relief Wells	IEIT	Screened
3D	Relief Wells	Sheet Wall	Screened
4A	**Partial Weighted Filter Berm & Partial Relief**	**Filter**	**Advanced**
4B	Partial Weighted Filter Berm & Partial Relief Wells	Relief Wells	Screened
4C	Partial Weighted Filter Berm & Partial Relief Wells	IEIT	Screened
4D	Partial Weighted Filter Berm & Partial Relief Wells	Sheet Wall	Screened
5A	Partial Weighted Filter Berm & Partial Toe Drain	Filter	Screened
5B	Partial Weighted Filter Berm & Partial Toe Drain	Relief Wells	Screened
5C	Partial Weighted Filter Berm & Partial Toe Drain	IEIT	Screened
5D	Partial Weighted Filter Berm & Partial Toe Drain	Sheet Wall	Screened
6A	**IEIT**	**Filter**	**Advanced**
6B	IEIT	Relief Wells	Screened
6C	IEIT	IEIT	Screened
6D	IEIT	Sheet Wall	Screened
7A	**Partial IEIT & Partial Weighted Filter Berm & No Action**	**Filter**	**Advanced**
7B	Partial IEIT & Partial Weighted Filter Berm & No Action	Relief Wells	Screened
7C	Partial IEIT & Partial Weighted Filter Berm& No Action	IEIT	Screened
7D	Partial IEIT & Partial Weighted Filter Berm & No Action	Sheet Wall	Screened
8A	Partial IEIT & Partial Relief Wells & No Action	Filter	Screened
8B	Partial IEIT & Partial Relief Wells & No Action	Relief Wells	Screened
8C	Partial IEIT & Partial Relief Wells & No Action	IEIT	Screened
8D	Partial IEIT & Partial Relief Wells & No Action	Sheet Wall	Screened
9A	Partial IEIT & Partial Toe Drain & No Action	Filter	Screened
9B	Partial IEIT & Partial Toe Drain & No Action	Relief Wells	Screened
9C	Partial IEIT & Partial Toe Drain & No Action	IEIT	Screened
9D	Partial IEIT & Partial Toe Drain & No Action	Sheet Wall	Screened
10A	**IEIT & Partial Weighted Filter Berm**	**Filter**	**Advanced**
10B	IEIT & Partial Weighted Filter Berm	Relief Wells	Screened
10C	IEIT & Partial Weighted Filter Berm	IEIT	Screened
10D	IEIT & Partial Weighted Filter Berm	Sheet Wall	Screened

4.2.1. Ponding Area (PFM1A-4) Screening

Three of the four different possible options identified to address risks from PFM 1A-4 were eliminated from further consideration; which reduced the number of total alternatives from 40 to 10. The following provides a brief summary of the three eliminated options.

Ponding Area Option B included the installation of a minimum of seven relief wells surrounding the ponding area to meet the desired reduction in risk. However, this option was screened from further consideration because the cost of installing and maintaining these wells would be high, especially when compared to Ponding Area Option A (discussed in **Section 4.3**).

Ponding Area Option C was an IEIT between the levee and the ponding area. However, this option was screened from further consideration, as gravity flow pipes leading to and from the ponding area, the proximity of the levee to the ponding area, and infrastructure associated with the pump station would make constructing this feature safely and properly extremely difficult, if not impracticable.

Ponding Area Option D was a sheet pile interceptor at the ponding area. This was also screened from further consideration for the same reasons as Ponding Area Option C. Additionally, there was concern a sheet pile interceptor may not be as effective as a properly constructed IEIT.

This leaves only **Ponding Area Option A** as the last remaining reasonable measure to address risks from PFM 1A-4. Ponding Area Option A is described in detail in **Section 4.3**.

4.2.2. Ball Field Reach (PFM1A-2) Screening

Five of the 10 different possible options identified to address risks from PFM 1A-2 were eliminated from further consideration, which reduced the number of total action alternatives from 10 to five. The following provides a brief summary of the five eliminated options.

Ball Field Option 1 consisted of a weighted filter berm installed along the Ball Field Reach to resist uplift pressures as well as filter any material that did escape at a concentrated seepage exit or boil. Preliminary design of this option indicated that nearly one-third of Zoar Village, including 25 structures and some of the more significant historic sites, would have to be purchased and removed for this measure to provide the desired reduction in risk (**Figure 4-1**). Traditional design guidance would suggest a berm width of 300 to 400 feet from the levee would suffice. However, even with this reduction in the extent of the weighted filter berm, implementation of this option would cause significant impacts; including drastically reducing the benefits the levee provides. Therefore, **Ball Field Option 1 was screened from further consideration**.

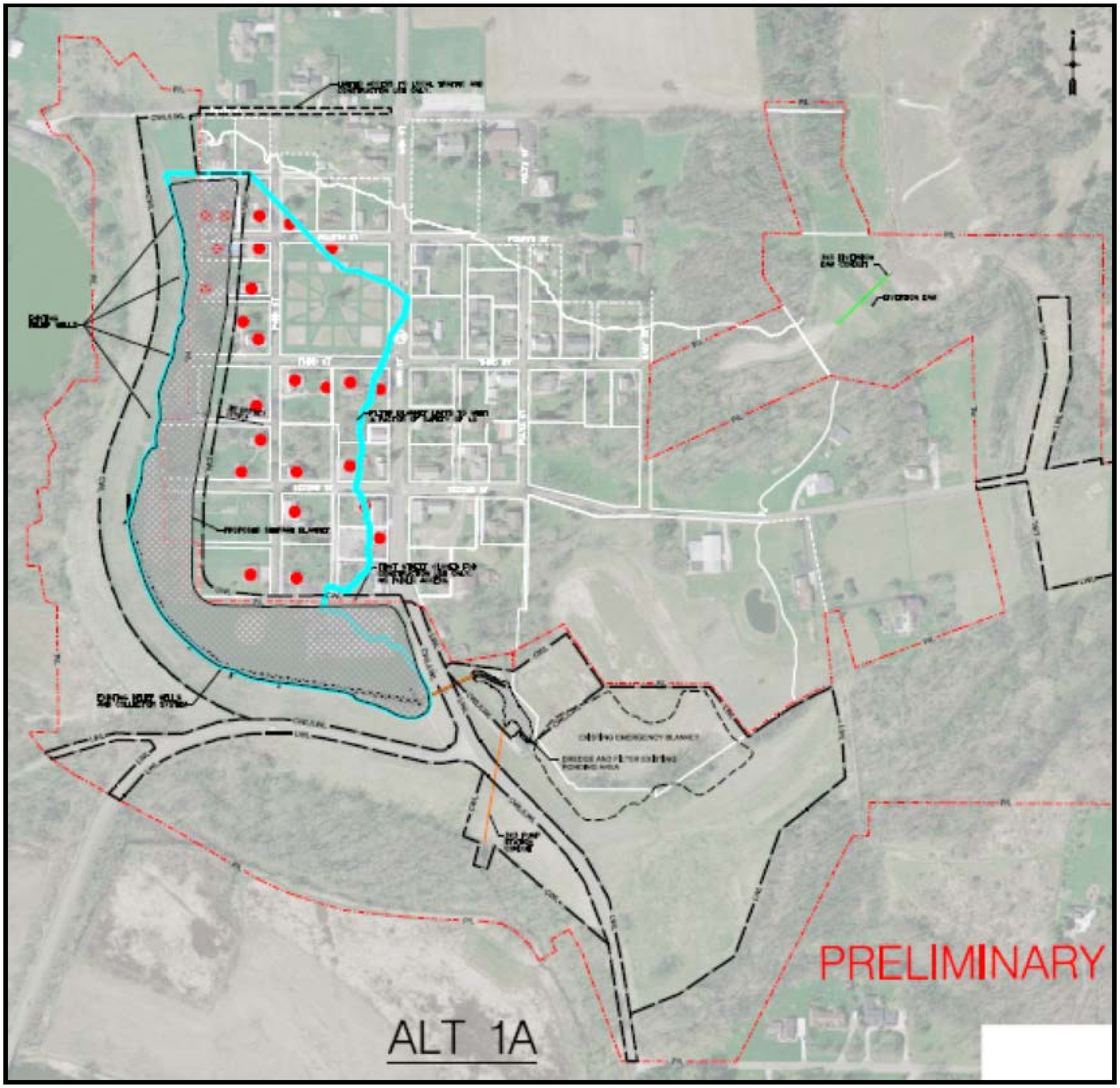

Figure 4-1 Ball Field Option 1 plan view showing extent and impacts.

Ball Field Option 2 consisted of a full-length toe drain installed along the Ball-Field Reach to reduce pressures by collecting seepage and then sending it to the ponding area to be pumped out (**Figure 4-2**). The toe drain would be backfilled with material to secondarily act as an IEIT. However, toe drains are not the most appropriate remedy for reducing pressures caused by seepage in areas where deep pervious foundation conditions exist, such as those found at Zoar Levee.

This became apparent when laying out the expected depth (20-30 feet) and required capacity (~20 feet radius) of the toe drain to achieve the desired reduction in risk. Because the toe drain would be excavated in highly granular material, the need for a sloped excavation was also considered. Finally, the toe drain was expected to collect enough seepage that consideration to expanding the ponding area and or adding additional pump capacity would be required to avoid transferring risk. When these issues were combined, the toe drain became an expensive solution which required the purchase of three residences and two historical buildings in Zoar Village (**Figure 4-2**).

Given that other options existed with less constructability issues, that are more appropriate for a deep pervious foundation, and could be implemented for less cost, **Ball Field Option 2 was screened from further consideration**.

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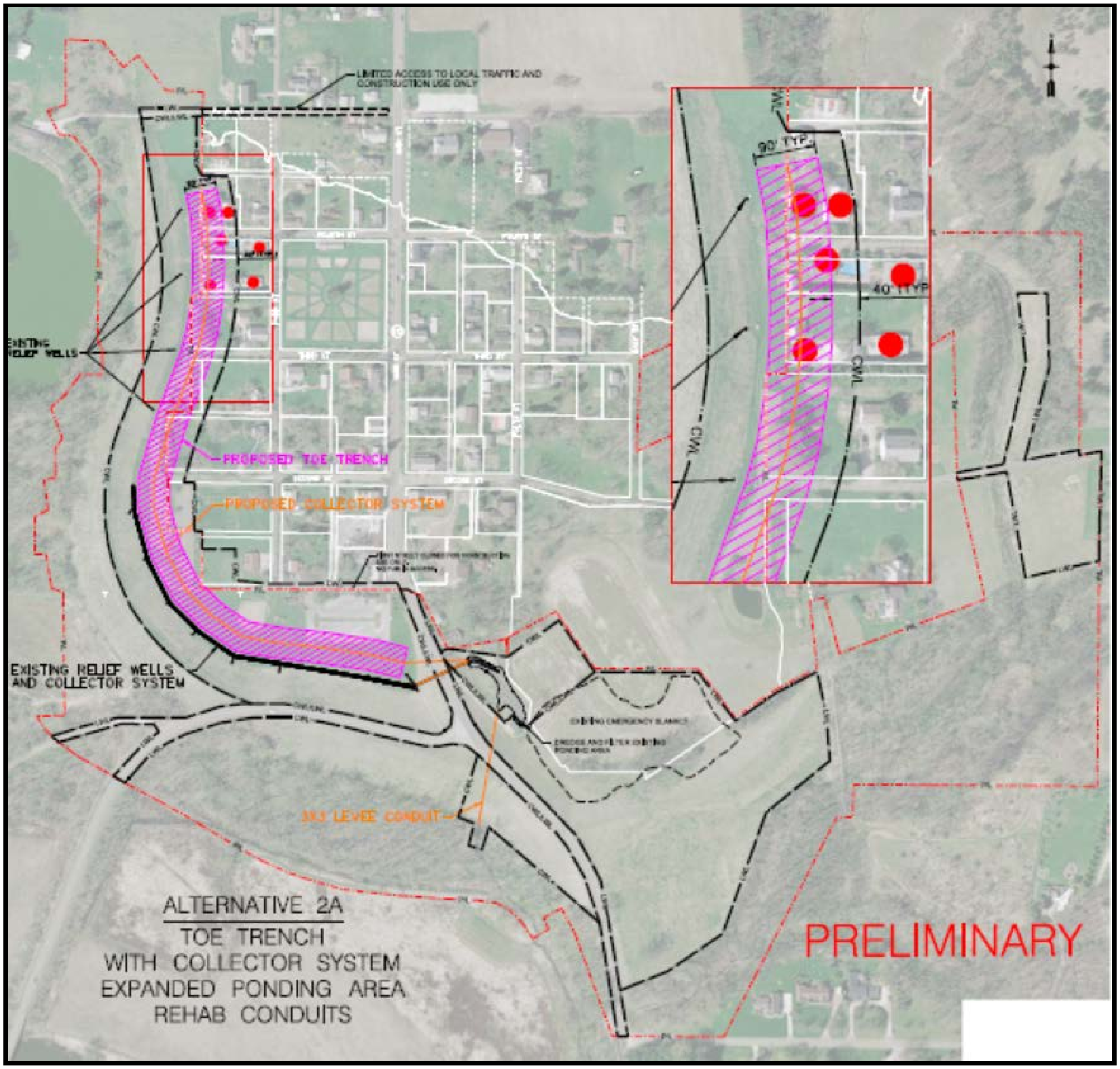

Figure 4-2 Ball Field Option 2 plan view showing extent and impacts.

Ball Field Option 5 consists of a partial length toe drain similar to that described for Ball Field Option 2 (**Figure 4-3**). However, in this alternative, the toe drain would be installed between Fourth and Second Streets. From this point, a collector pipe would continue to the ponding area. Between Third Street and State Route 212, the toe drain is replaced with a weighted seepage berm. This treatment was formulated to take advantage of real estate available along the southern portion of the Ball Field Reach to install a weighted seepage berm without impacting houses and structures and reduce the amount of excavation required for the toe drain.

However, this measure was also screened for the same reasons as Ball Field Option 2. Mainly, the purchase and demolition of historic homes, including associated mitigation, would still be required, and the toe drain is not an ideal solution for an area with a deep pervious foundation. Given other more reasonable and less expensive and impactful solutions existed, **Ball Field Option 5 was screened from further consideration**.

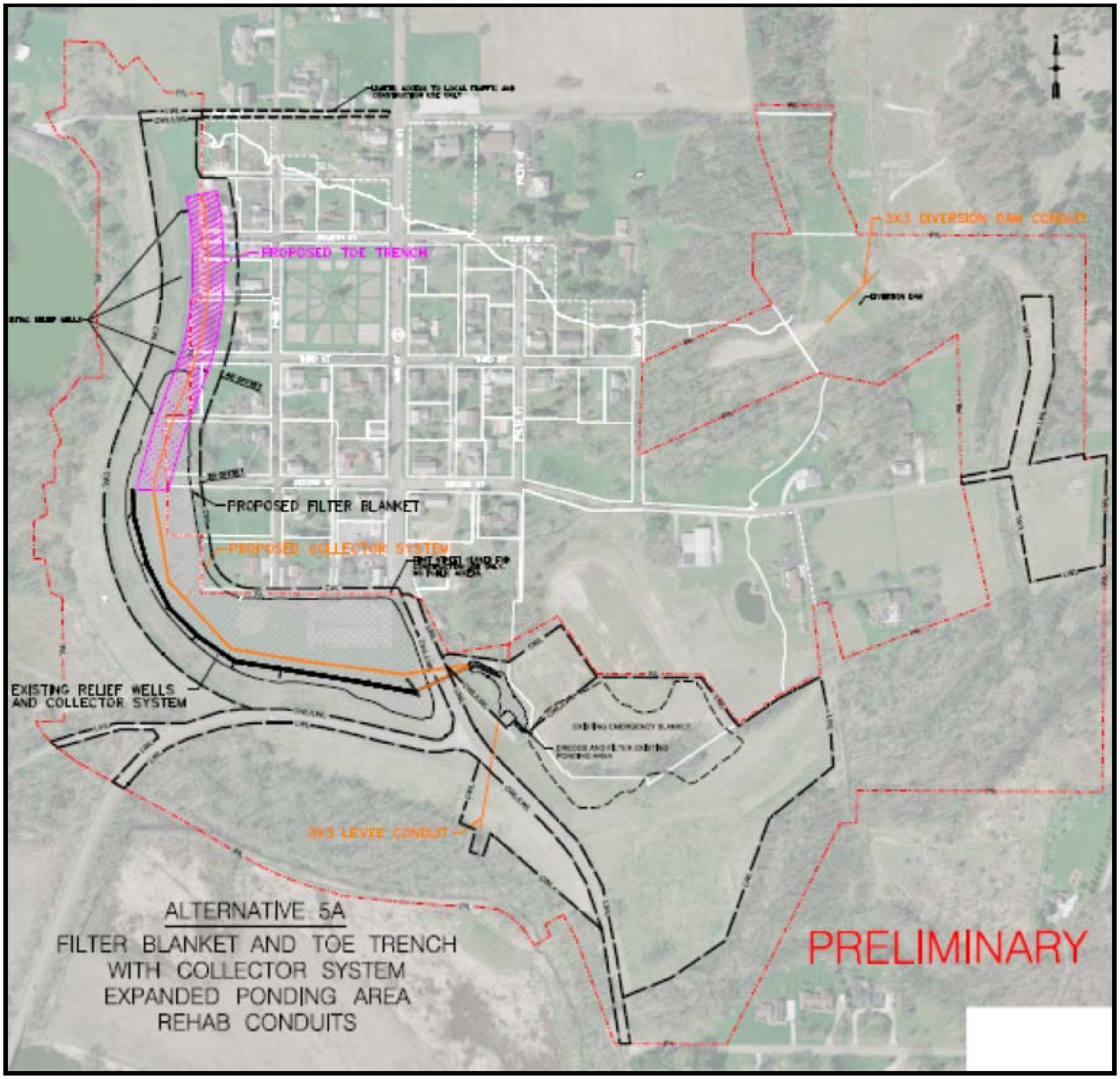

Figure 4-3 Ball Field Option 5 plan view showing extent and impacts.

Ball Field Options 8 and 9 were formulated as slight alternatives to Ball Field Option 7. Ball Field Option 7 (discussed in **Section 4.3.5**) consists of three reach-specific treatments; (1) an IEIT, (2) taking no action, and (3) a weighted filter berm.

In summary, Ball Field Options 8 and 9 involve two of the same measures: (1) installing an IEIT and (2) taking no action. Ball Field Option 8 included the installation of relief wells for the third reach treatment. Ball Field Option 9 included the installation of a toe drain for the third reach treatment. **Ball Field Options 8 and 9 were eliminated from further consideration**, as they are more expensive and unlikely to prove to be more effective than Ball Field Option 7.

This leaves only **Ball Field Options 3, 4, 6, 7 and 10** as the last remaining options to address risks from PFM 1A-2. These options are described in detail in **Section 4.3**.

4.3. Final Array of Action Alternative Risk Management Plans

The final array of action alternatives is presented in **Table 4-3** below. Per requirements set forth in NEPA, ER 1110-2-1156 and ER 1105-2-100, No Action must be included in a final array of alternatives. Refer to **Appendix I** for a full description of the engineering analysis behind the final array of action alternatives. The benefits and impacts to risks and the affected environment from the final array are summarized in **Chapter 5.0**.

As noted in **Table 4-3**, each of the final array of alternatives includes an IEIT or Partial Length IEIT. This was the result of a realization that each of the final array of alternatives required the excavation of a trench, either for the specific purpose of installing an IEIT, or as a collector for the relief wells. Therefore, it was decided to take advantage of these excavations to back fill them with a material to arrest backward erosion piping for a small cost to add some redundancy to some alternatives. The nature of the backfill and construction methods used to install the IEIT shall be determined based on the results of investigations undertaken during design.

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Table 4-3 Final Array of Action Alternatives.

ACTION ALT	BALL FIELD OPTIONS (PFM1A-2)	PONDING AREA OPTIONS (PFM1A-4)
3A	Relief Wells & IEIT	Filter
4A	Partial Weighted Filter Berm & Partial Relief Wells & IEIT	Filter
6A	IEIT	Filter
7A	Partial Length IEIT & Partial Weighted Filter Berm & No Action	Filter
10A	IEIT & Partial Weighted Filter Berm	Filter

For each action alternative, the construction work limits would be similar, with slight variations in the total acreage required. Generally speaking, construction work limits would be located adjacent to the levee and near the intersection of 2nd Street and the diversion channel. The latter location would be reserved as a staging location. Actual construction activities would take place along the toe of the Ball Field Reach and surrounding the ponding area.

Construction access to the Ball Field Reach would be from 5th and 1st Streets. For the ponding area, access shall be accomplished via an existing road to the pump station or via the Rock Knoll over the emergency blanket. Dredged material would be spread over the area shown for disposal in **Figure 4-4** below. This area has been utilized for periodic dredge disposal, which occurs usually every 10 years.

Any borrow material required for filters, the IEIT, or weighted filter berm would be commercially purchased aggregate, and disposal would be accomplished on site, either along the Ball Field Reach or at the nearby Rock Knoll. All disturbed areas would be restored.

4.3.1. Ponding Area Option A of Action Alternatives 3A, 4A, 6A, 7A and 10A

Ponding Area Option A would be common to all action alternatives in the final array. It is described once and will not be repeated. Ponding Area Option A consists of:

1. Dredging the existing sediment within the ponding area to a depth of approximately 5-7 feet;
2. Replacing this dredged material with an approximate four foot thick gravel filter; and
3. Armoring the filter with stone large enough to allow for periodic dredging of the ponding area without damaging the underlying filter material.

Figure 4-4 is a plan view showing the location of the ponding area. **Figure 4-5** shows a cross section of what is being proposed.

To help install the reverse filter, the gate at the diversion dam may be closed temporarily to eliminate input into the ponding area from Goose Run and pumps may be used to help remove water from the ponding area while the reverse filter is being installed.

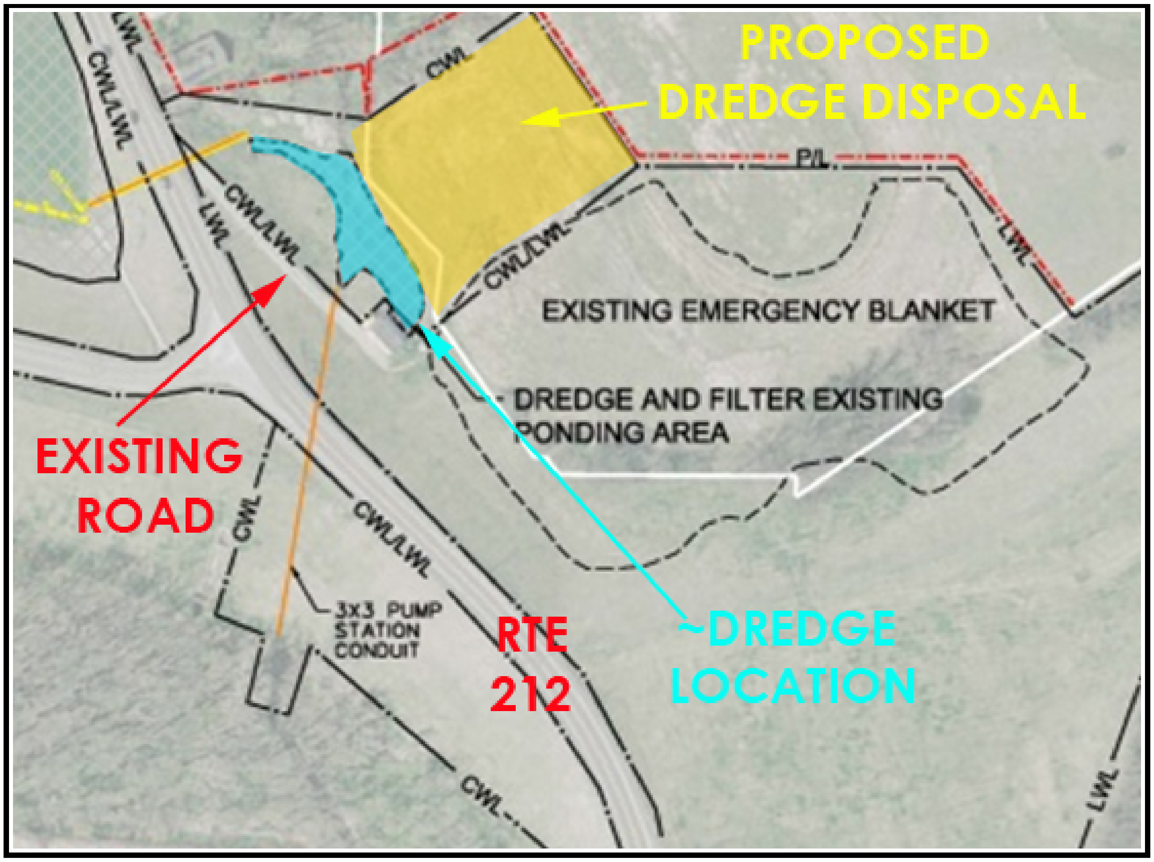

Figure 4-4 Ponding Area Option A plan view.

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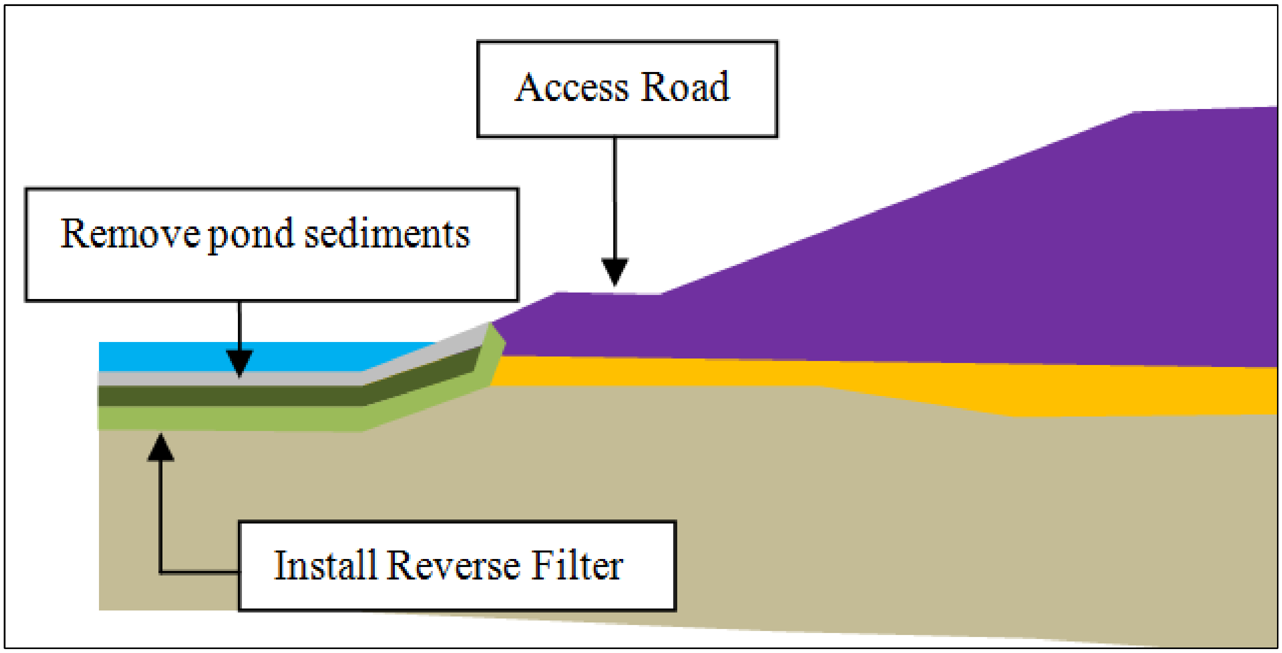

Figure 4-5 Ponding Area Option A cross section.

4.3.2. Ball Field Option 3 of Action Alternative 3A

Ball Field Option 3 consists of two principle measures as shown below in **Figure 4-6**, including:

1. 20 new relief wells from 5th Street (Station 1+50) to State Route 212 (Station 24+50); and
2. A full-length IEIT, as described in **Section 4.3.4**.

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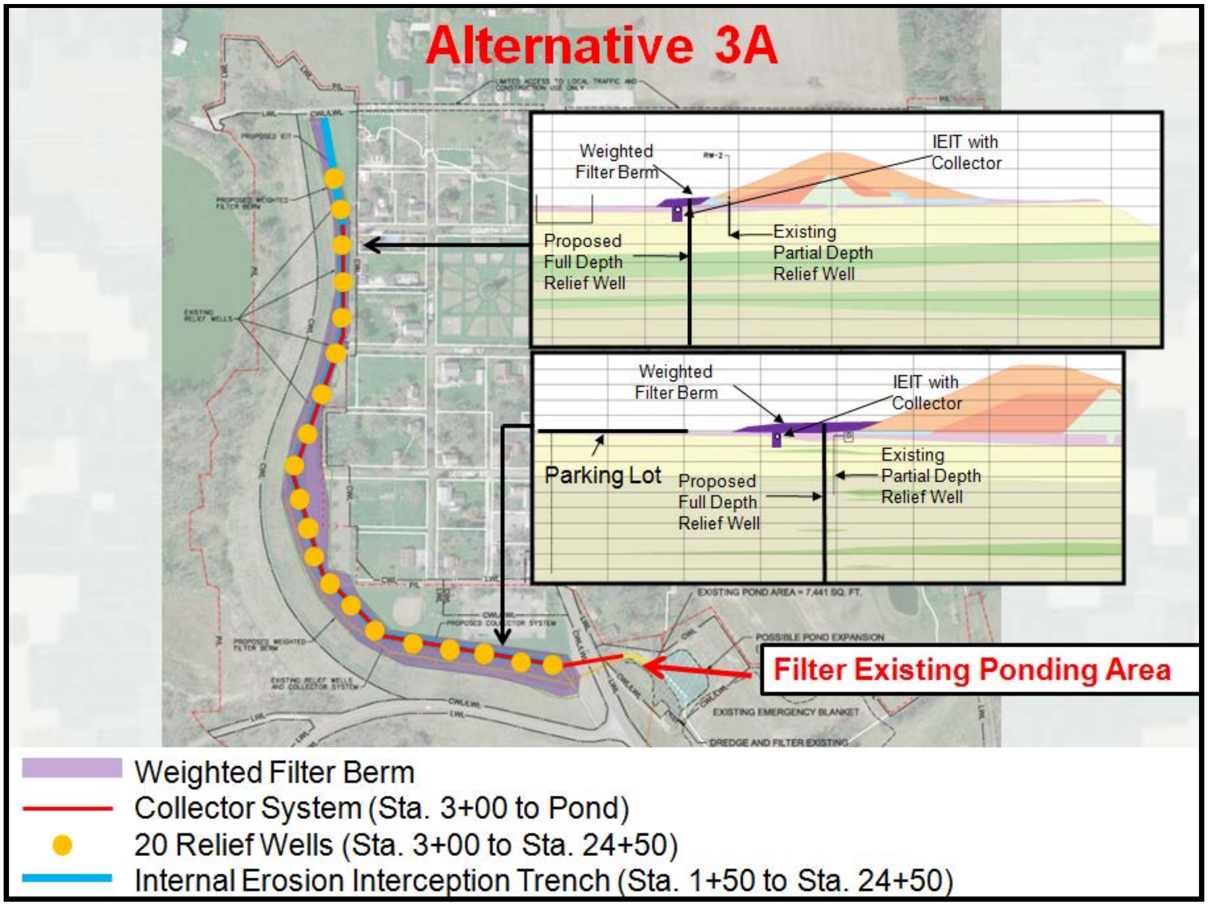

Figure 4-6 Option 3A plan view and cross sections.

The first measure would draw down water pressures and reduce the probability of the confining layer to heave. This would help the confining layer stay intact; reducing the likelihood underseepage could erode any foundation soils and allow backward erosion piping to begin. Put another way, this option is designed to reduce the potential for PFM 1A-2 even starting.

The wells were assumed to penetrate the full aquifer, to bedrock, and designed to provide acceptable factors of safety for heave of the confining layer for an impoundment of El. 916 feet. This corresponds to Dover Dam's spillway, which is the highest elevation at which a pool would be held for a significant duration. Calculations indicated the amount of risk reduction from adding relief wells for higher impoundments was not cost effective.

A collector system to direct water to the ponding area, via a bored and jacked pipe under Route 212, would also be installed. The collector system includes a buried pipe. The trench excavated for this pipe would be backfilled to serve as an IEIT which adds some redundancy in the event heaving and piping does begin. It is anticipated part of the collector pipe would have to be buried by a small berm to stay below the ground surface. This feature would collect and send additional water to the pump station, but not enough to significantly increase the risk of the pumps being overwhelmed.

The construction work limits would encompass approximately 29 acres.

4.3.3. Ball Field Option 4 of Action Alternative 4A

Ball Field Option 4 consists of three principle measures as shown in **Figure 4-7**, including:

1. A line of ten new relief wells between 5th Street (Station 1+50) and just south of 1st Street (Station 16+00);
2. A weighted filter berm between 3rd Street (Station 8+00) wrapping around to State Route 212 (Station 24+50); and
3. A full length IEIT as described in **Section 4.3.4**.

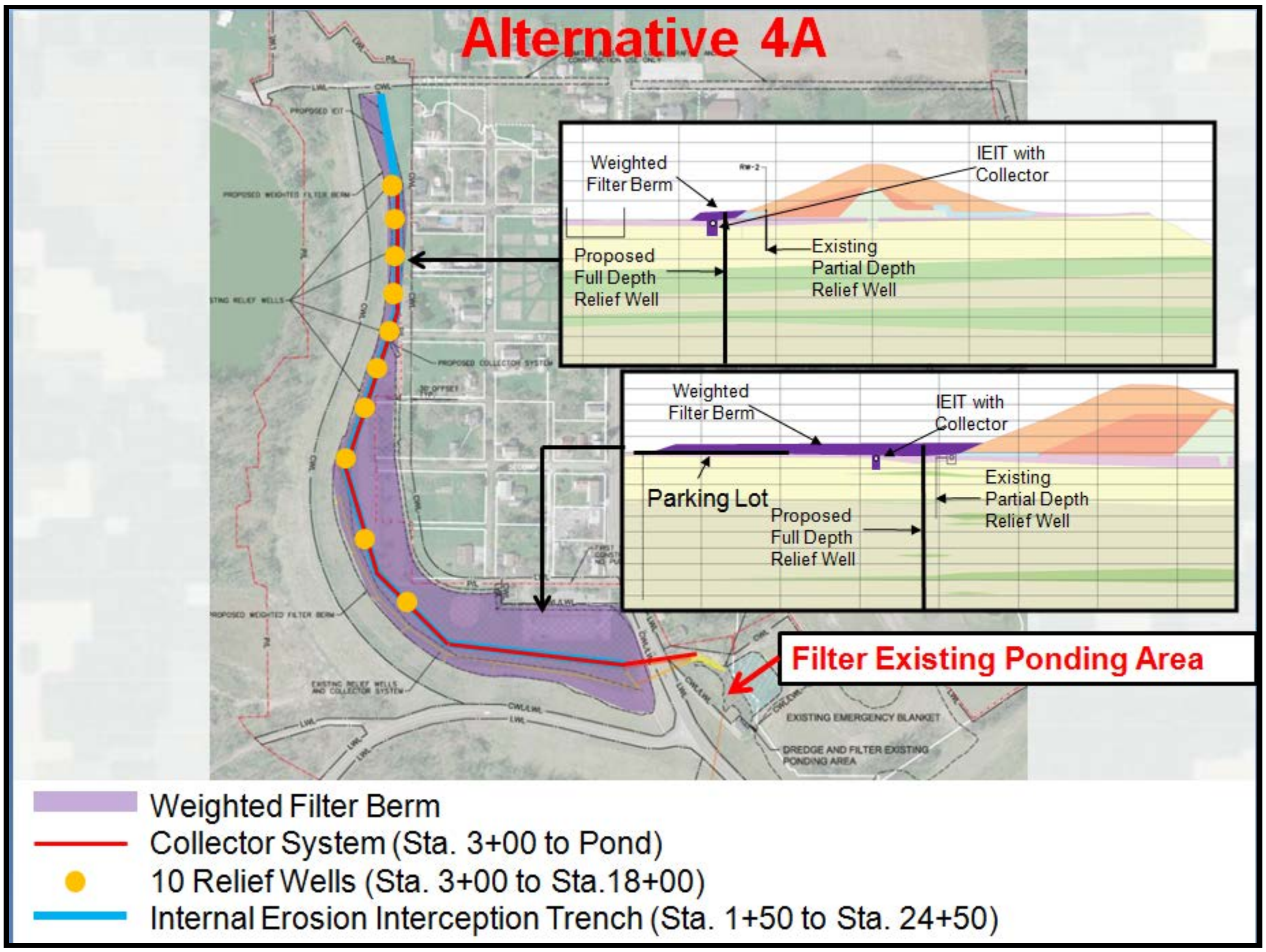

Figure 4-7 Option 4A plan view and cross sections.

The first two measures work in combination to reduce the chance of heave of the confining layer. Put another way, this option is designed to reduce the potential for PFM 1A-2 even starting. Also included is the same collector pipe and IEIT from Ball Field Option 3, which adds some redundancy in case heaving and piping does begin.

This option is designed to meet the same factor of safety as Ball Field Option 3, while essentially trading off half of the wells for a larger berm. This design was optimized to concentrate wells in the northern portion of the Ball Field Reach where structures are located very near to the embankment, and rely on the berm mostly in the southern portion where there is more available real estate. The relief well design is basically unchanged from Ball Field Option 3.

The weighted filter berm is generally 150 to 200 feet in width, and three to seven feet thick. As with all the berms in the Ball Field Options for the final array, it is composed of half sand and half gravel (for drainage), and is intended to provide additional weight to resist the water pressures beneath the confining layer. Similar to the relief wells, it would reduce the probability of the confining layer to heave. This would help the confining layer stay intact; reducing the likelihood underseepage could erode any foundation material and allow backward erosion piping to begin.

As discussed previously, the confining layer is thought to be intermittent. At these locations, the berm would prevent any foundation material from eroding out with seepage. Furthermore, it covers all of the areas of confirmed prior performance issues in the Ball Field Reach.

The construction work limits would encompass approximately 30 acres.

4.3.4. Ball Field Option 6 of Action Alternative 6A

Ball Field Option 6 consists of one principle measure: an IEIT to arrest backward erosion piping that may have started (see **Figure 4-8** below). It is not intended to reduce water pressures in the sands and gravels or affect the initiation of piping. Put another way, this option is designed to reduce the probability PFM 1A-2 would continue to a breach, but does not reduce the probability of the failure mode starting. Therefore, this option would not reduce the amount of seepage or boils expected to occur for any future event.

The IEIT would extend through the upper confining layer and at least five feet into underlying sands and gravels. It would be backfilled with coarse sand and/or fine gravel that would be able to arrest piping channels eroding backward toward the levee. As detailed in **Appendix I**, geotechnical investigations would be undertaken prior to construction to better define the type of backfill required.

Existing infrastructure requires the IEIT to be offset from the levee toe, so a small, weighted filter berm would be constructed from the IEIT back to the levee. This small berm is intended to provide weight to resist heave of the confining layer in this area.

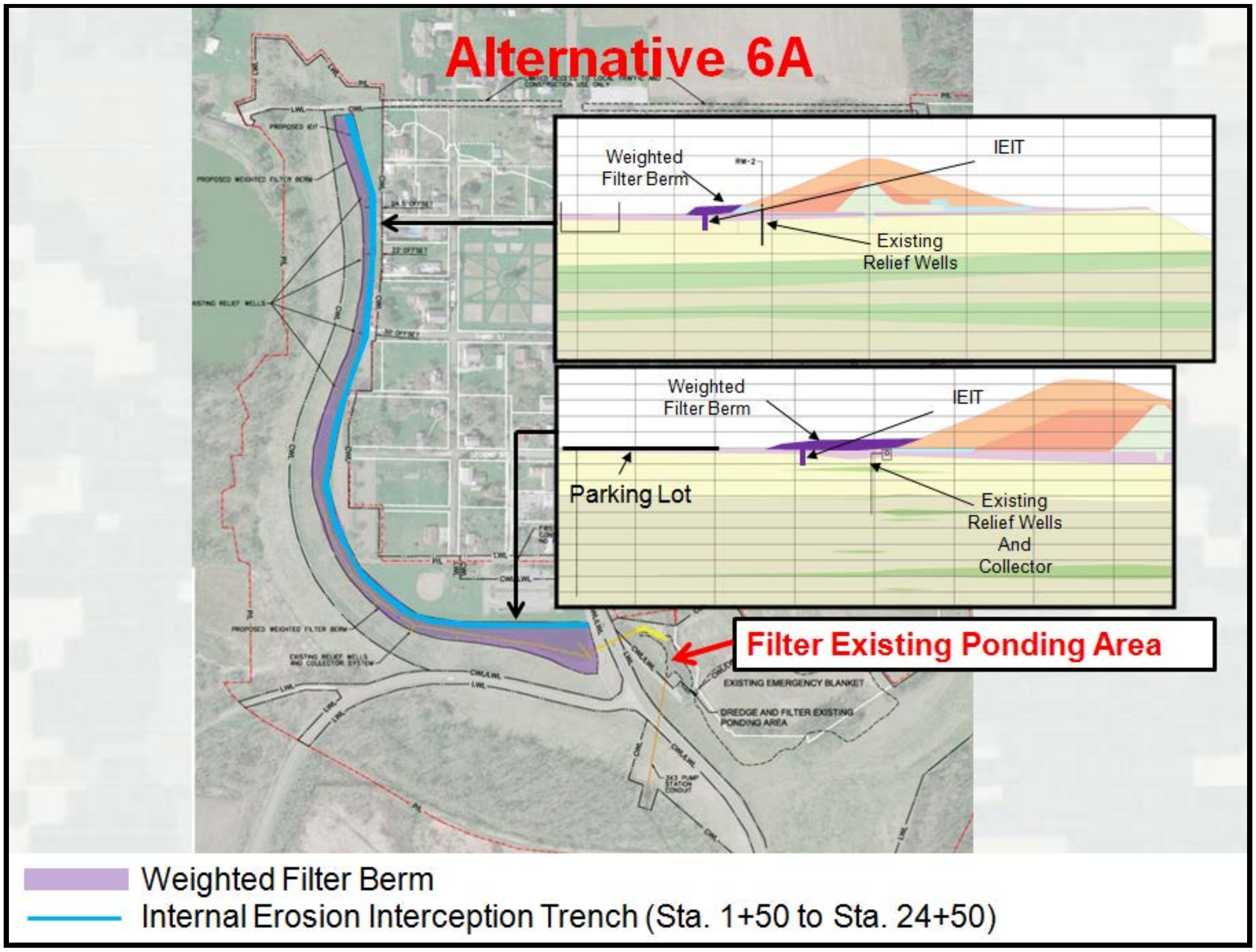

Figure 4-8 Option 6A plan view and cross sections.

No pipe would be included in this option, so no boring and jacking is required, and an insignificant amount of additional seepage is expected on the ground surface.

The construction work limits would encompass approximately 29 acres.

4.3.5. Ball Field Option 7 of Action Alternative 7A

Ball Field Option 7 consists of three principle measures in three sub-reaches as shown below in **Figure 4-9**, including:

1. An IEIT, as described in **Section 4.3.4**, between 5th Street (Station 1+50) and 2nd Street (Station 12+00);

2. Taking No Action between 2nd Street (Station 12+00) and 3rd Base Line of the Little League Ball Field (Station 19+00)
3. A weighted filter berm, similar to the one described in **Section 4.3.3**, between the 3rd Base Line of the Little League Ball Field (Station 19+00) and State Route 212 (Station 24+50).

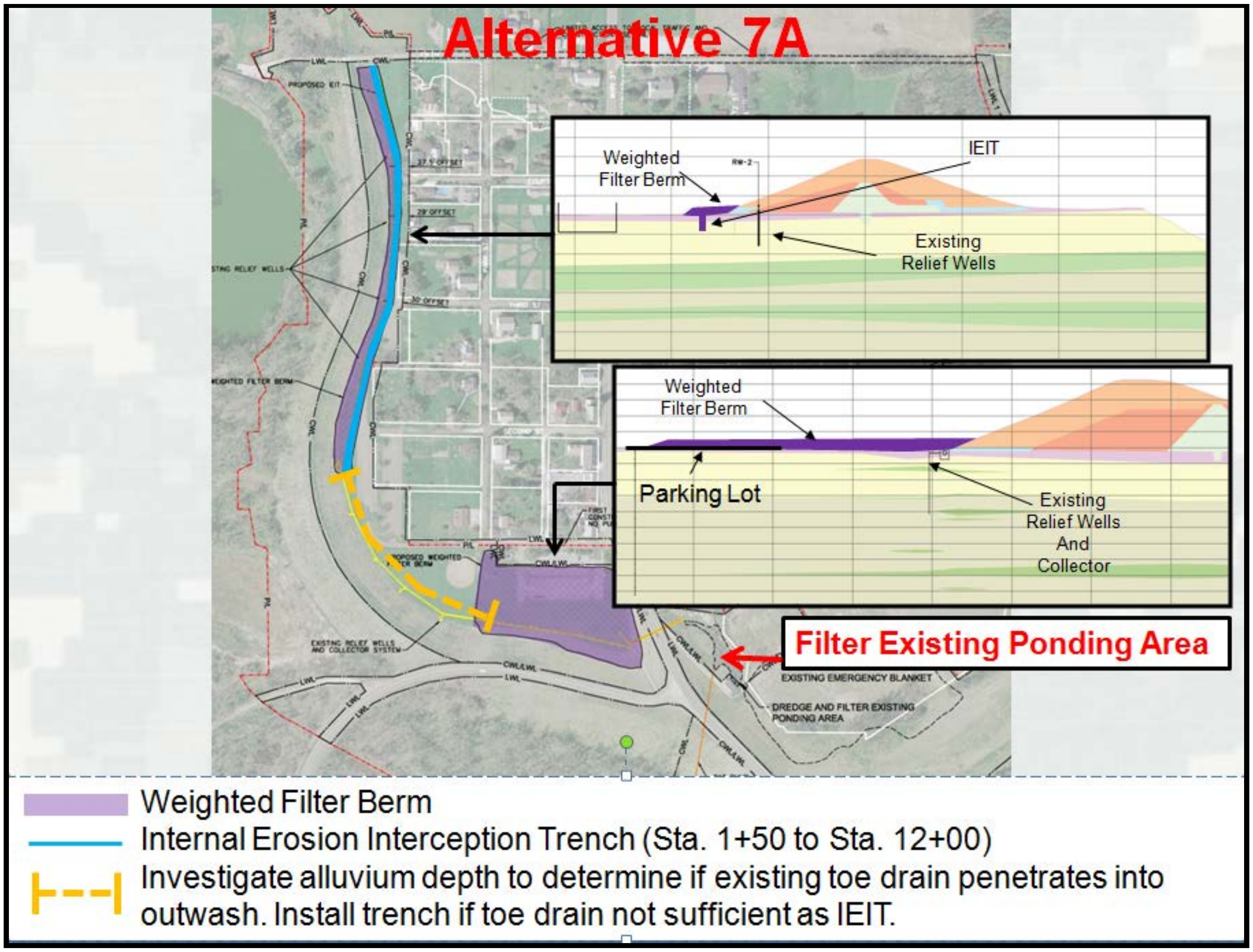

Figure 4-9 Option 7A plan view and cross sections.

Ball Field Option 7 was developed with the recognition that the existing toe drain / collector system trench, although not designed as such, could function like an IEIT where it penetrates the confining layer.

There is no existing trench in Sub-reach 1 and the confining layer is expected to be shallow enough to penetrate the IEIT. It is suspected the existing toe drain / collector system does penetrate the confining layer in Sub-reach 2. Shallow investigations would be performed between the new IEIT and weighted filter berm to determine if the existing trench penetrates the confining layer and extends into the underlying sands and gravels. A new IEIT would be constructed along any portions where the toe drain / collector trench was found to be of insufficient depth. The confining layer is known to be much deeper in Sub-reach 3. Additionally, there are no nearby buildings or structures in Sub-reach 3, making a weighted filter berm at this location more reasonable.

The construction work limits would encompass approximately 29 acres.

4.3.6. Ball Field Option 10 of Alternative 10A

Ball Field Option 10 consists of two principle measures as shown below in **Figure 4-10**, including:

1. An full length IEIT as described in **Section 4.3.4**; and
2. A weighted filter berm as described in **Section 4.3.3**.

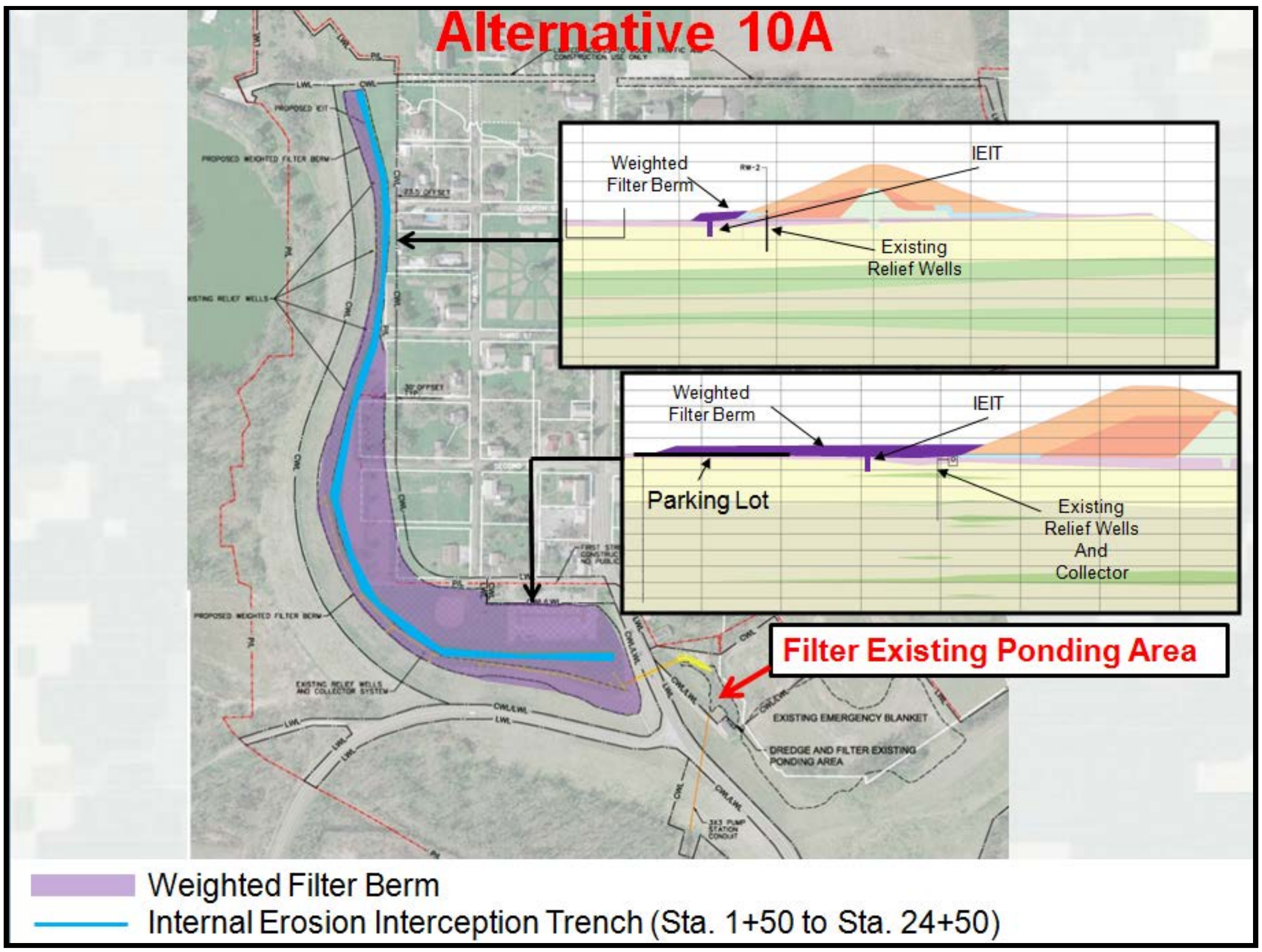

Figure 4-10 Option 10A plan view and cross sections.

This option is essentially the same as Ball Field Option 4 with the relief wells and associated collector pipe removed.

The construction work limits would encompass approximately 30 acres.

4.4. FWAC / No Action Alternative

The FWAC / No Action alternative is detailed in **Section 3.3**. In summary, the following is expected over the next 50 years, absent inundation due to levee breach, pump failure, or overtopping.

- USACE would operate and maintain Zoar Levee & Diversion Dam;
- USACE would conduct maintenance on electrical/mechanical equipment and maintain and rehabilitate relief wells;
- USACE would continue surveillance and flood-fighting as required;
- USACE would provide a positive LSE for Zoar Levee to withstand the base flood;
- FEMA would accredit Zoar Levee to withstand the base flood;
- Zoar Village would continue;
- No other agency or organization would implement any further risk management actions at Zoar Village;
- USACE would reduce pump inundation risks below USACE Tolerable Risk Guidelines using maintenance packages; and
- Incremental inundation risks associated with breach would remain outside of USACE Tolerable Risk Guidelines; but should not appreciably increase or decrease.

Costs associated with operating and maintaining the project, including labor, utilities, mowing and vegetation controls, repairing or replacing electrical and mechanical equipment, and relief well maintenance and the costs of taking action to lower inundation risk from pump failure are summarized in **Table 4-4** below.

Table 4-4 FWAC/No Action costs.

Component	Cost
Standard O&M	~$**4,305,650**
Lower pump inundation risks	~$750,000
Total Cost	**~$5,055,650**

As reported in **Section 3.3.2.4**, additional flood fighting costs may also be incurred over the next 50 years.

With the exception of relief well maintenance and flood fighting costs, all of these FWAC/No Action costs are expected to be incurred for each of the action alternatives. The changes in relief well maintenance and flood-fighting costs for each action alternative are reported in **Chapter 5.0** and **Chapter 6.0**.

4.5. Summary of Final Array of Risk Management Alternatives

In summary, a full array of reasonable measures and alternatives were considered in order to lower incremental risks to within USACE Tolerable Risk Guidelines using ALARP Considerations. The focus of alternative formulation was to find reasonable actions which could lower incremental risks from PFM 1A-2 and PFM 1A-4, both of which were concerned with scenarios where backward erosion piping could lead to levee breach.

Non-structural Measures were considered to manage risks without modifying the levee but were eliminated from further consideration, as they were either inappropriate given the estimated risk condition, highly expensive and/or impactful.

Structural measures were considered to manage risks by modifying the levee. In summary, these included methods for replacing the project, preventing seepage from occurring or managing the seepage to lower the probability of backward erosion piping from occurring and/or progressing underneath the levee. Only seepage management measures were carried forward.

Analysis indicated that given the estimated risk conditions, five reasonable action alternatives exist to meet the purpose and need. The action alternatives were designed to:

- Reduce the probability of backward erosion piping starting, by lowering the water pressures placed on the Village-Side of the levee; and/or
- Reduce the probability of any backward erosion piping that started on the Village-Side of the levee progressing underneath the levee and leading to a breach.

The five action alternatives are made up of combined options to treat each PFM specifically.
For PFM 1A-4, one action option was determined to be the single most reasonable.

- **Action Option A** includes installing a reverse filter in the ponding area to both reduce the probability of backward erosion piping starting, and continuing if it did start.

For PFM 1A-2, five reasonable action options were designed to address risks at the Ball Field Reach.

- **Action Option 3** reduces the probability of backward erosion piping starting, using relief wells. If backward erosion were to occur, a full-length IEIT installed as part of a collector would secondarily reduce the potential it would lead to a breach. This option also includes a small weighted filter berm between the landward levee toe and the IEIT.

- **Action Option 4** reduces the probability of backward erosion piping starting, using a combination of relief wells and a weighted filter berm. If backward erosion piping were to occur, the weighted filter berm, and a full-length IEIT installed as part of a collector, would secondarily reduce the potential it would lead to a breach.
- **Action Option 6** reduces the probability that backward erosion piping, if it were to occur, would lead to a breach, using a full-length IEIT. This option also includes a small weighted filter berm between the landward levee toe and the IEIT.
- **Action Option 7** relies on the existing collector system and a reach specific partial-length IEIT to reduce the probability that backward erosion piping, if it were to occur, would lead to a breach. A reach-specific weighted filter berm also reduces the probability of backward erosion piping starting and would secondarily reduce the potential it would lead to a breach, if it were to occur.
- **Action Option 10** relies on a combination of an IEIT and weighted filter berm to reduce the potential that backward erosion piping, if it were to occur, would lead to a breach. The weighted filter berm would also reduce the probability that backward erosion would begin.

A **FWAC/No Action scenario** has also been developed to forecast what the risk would be absent of a dam safety project.

In **Chapter 5.0**, the final array of action alternative risk management plans are evaluated against the FWAC/No Action alternative.

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5.0 EVALUATON OF ALTERNATIVES

To determine the most likely condition expected under each action alternative risk management plan, an assessment of risk reduction, and the plan's effects on life safety, economics and environment must be considered. Further, the contributions to Dam Safety objectives from each alternative risk management plan must be assessed. Beneficial and adverse effects of each plan must be evaluated. This information is then compared against the FWAC/No Action alternative.

5.1. Methods

The following methods were used to evaluate the action alternative risk management plans.

5.1.1. Likely Reduction in Annual Probability of Failure

As discussed in **Section 3.3.2.7**, it is not anticipated the leveed area's population and built environment would significantly change in the foreseeable future. None of the action alternative risk management plans involve changes in the leveed area's population or built environment. As annual probability of failure is reduced, the potential for consequences to occur would also be reduced. Therefore, the focus of the evaluation of risk was on the ability to reduce the annual probability of failure.

As previously discussed, PFM 1A-2 and PFM 1A-4 were identified as the drivers of breach risk at Zoar Levee. Both PFMs had the possibility to have more than 1 in 10,000 chances of occurring annually, which is above the USACE TRLL. To determine how well the final array of alternatives would reduce the annual probabilities of failure, numerical probabilities were assigned to all events in each failure mode. A combination of engineering analysis and team opinion based on available evidence was used to estimate numerical probabilities of each failure mode which could be affected by the alternative. This forecast of risk was then compared to the existing risk condition to determine the expected risk reduction for each alternative. A thorough description of this process is included in **Appendix B**.

Uncertainty in the forecasted probability was captured by considering factors that may contribute to the action alternative not performing as intended. The intent was not to evaluate a "Worst Case" condition, but rather to incorporate uncertainties in foundation conditions, design assumptions, and potential issues related to construction of each alternative which would result in less favorable performance. Two alternative "Outcomes" were established and are defined below:

> "As Intended" – Risk expected given proposed action alternative is constructed as designed and given our current understanding of site conditions (what we expect to happen when it is installed as designed); and

"Less Favorable" - Risk reasonably expected from the proposed action alternative, after consideration of factors which could compromise the effectiveness of the alternative (foundation uncertainty, construction issues), as well as a number of Evaluation Factors (**Section 5.1.1.1**).

Risk for the "As Intended" outcome was elicited first. Then, issues that could contribute to overall performance of the project, both positive and negative, were discussed. After this, the team considered "Evaluation Factors" described in the next section. Taking all of these factors into account, the "Less Favorable" outcome was elicited for each alternative.

5.1.1.1. Evaluation Factors Affecting Reduction of Annual Probability of Failure

In addition to eliciting the expected risk reduction for each alternative ("As Intended" outcome), each alternative was evaluated in consideration of the following factors: Completeness, Effectiveness, Robustness, Redundancy, Resiliency, "Do No Harm", Designability, Constructability, and Long-Term Operations & Maintenance (O&M) Simplicity. Definitions of each of these factors are included below:

- Effectiveness: The degree to which the action alternative meets the study objectives. Considers ratings of other evaluation factors.
- Completeness: The extent to which an action alternative risk management plan provides and accounts for all necessary investments or other actions to ensure the realization of the DSMS risk management objectives.
- Robustness: The ability of a system to continue to operate correctly across a wide range of operational conditions (the wider the range of conditions, the more robust the system), with minimal damage, alteration or loss of functionality.
- Redundancy: Duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or failsafe.
- Resiliency: The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or manmade, under all circumstances of use.
- Simplicity of Design (Designability): Is the action alternative easily designable? Were correct design assumptions made? Could oversimplification of design assumptions reduce the effectiveness? Are additional investigations required as part of the design?
- Simplicity of Construction (Constructability): How constructible is the action alternative? Can poor installation affect the end product performance? Is specialized equipment needed? Does the action alternative involve significant USACE presence during construction? Can the action alternative be easily modified during construction to account for a change in field conditions?
- Long-Term O&M Simplicity: Is long-term O&M for the action alternative relatively simple? Or would it create additional O&M complexity for project personnel?

- Do No Harm: The principle of "Do No Harm" must underpin all actions intended to reduce dam safety risk.

For each action alternative, factors were evaluated against the FWAC/No Action alternative. "Do No Harm" was evaluated "Yes" or "No". Remaining factors were rated by the team on a scale of 1-4. A summary of the rating scale for each factor is shown on **Table 5-1**. An average of the ratings for each factor was calculated, and used as the consensus value for that factor. These factors were considered in the elicitation of the "Less Favorable" outcome.

Table 5-1 Scale Used for Evaluation Factors

Evaluation Factors	Scale
Completeness	1=Not Complete 4=Complete
Effectiveness	1=Not Effective 4=Very Effective
Robustness - No Loss of Functionality	1=Not Robust 4=Very Robust
Redundancy (Duplicate Elements)	1=Not Redundant 4=Very Redundant
Resiliency (Survivability)	1=Not Resilient 4=Very Resilient
Designability	1=Complex 4=Simple
Constructability	1=Complex 4=Simple
Long Term O&M Simplicity	1=Complex 4=Simple

The results of this analysis are reported in **Section 5.2**.

5.1.2. Other Evaluation Factors

In addition to evaluating a range of factors affecting the ability to lower the annual probability of breach below the USACE TRLL, other factors were also considered to help evaluate and ultimately compare the alternatives.

- Efficiency: The extent to which an alternative is the most cost-effective means of achieving risk management objectives.
- Acceptability: The extent to which an alternative is acceptable in terms of laws, regulations and policies.

- Impacts to Affected Environment: The extent to which each alternative has the potential to impact or affect significant statutorily protected or regulated resources.

5.2. Alternative Evaluation Results

For descriptions of each action alternative, please refer to **Section 4.0**.

While the action alternatives were formulated to specifically address PFM 1A-2 and PFM 1A-4, they also had benefits to PFM 1A-1 and PFM 1A-3. As such, the following evaluation reports these reductions in risk as well. These action alternatives do not have risk reduction benefits to PFM 5A and PFM 6, both of which were well below the USACE TRLL. Therefore, these are not discussed.

The "Total" risk presented for each alternative is not the total of all of the levee PFMs. Rather, PFM 1A-1 through PFM 1A-3 are scenarios which could occur anywhere along the levee. After the APF is calculated for each of these scenarios for the "with project" condition, the highest risk of these three scenarios is added to PFM 1A-4, PFM 5A, and 6 to get the Total Risk.

Detailed discussion of evaluation of each action alternative is included in **Appendix B**.

5.2.1. Alternative Commonalities

The following are common factors to all alternatives and are discussed once.

5.2.1.1. Net Economic Benefits

While cost effectiveness was a key evaluation factor; none of the alternatives have annualized net benefits (see **Table 5-2** below).

Table 5-2 Action alternative costs & annualized net benefits projected for action alternative risk management plans

Action Alternatives	Cost*	Annual Net Benefits
3A	$16.99 M	-$966 K
4A	$17.53 M	-$905 K
6A	$8.01 M	-$488 K
7A	$9.32 M	-$547 K
10A	$13.02 M	-$705 K
*Includes Real Estate, Planning & Engineering During Design, Mitigation, Construction, Supervision & Administration, and Engineering During Construction (FY14 Price Level).		

See **Appendix D - Addendum 4** for more information on the NED Analysis.

5.2.1.2. Acceptability

Each alternative was also found to be acceptable in terms of all laws, policies, and regulations.

5.2.1.3. Duration

Each action alternative will take approximately 1.5 to 2 years to construct.

5.2.1.4. Ponding Area Option A (PFM 1A-4)

The filter associated with PFM 1A-4 is accounted for in the discussion below. However, as it is common to all action alternatives, much of the evaluation is focused on options at the Ball Field Reach to address PFM 1A-2. In summary, "As Intended" and "Less Favorable" outcomes for this alternative indicate installation of a filter at the ponding area would lower the probability of breach due to PFM 1A-4 below the USACE TRLL.

The main factors that contribute to the "As Intended" outcome include the benefits of having a filter at the base of the ponding area. Factors that may indicate a "Less Favorable" outcome largely result from having to install the filter in the wet.

Implementation of Option A would help make each alternative more robust and resilient than the FWAC/No Action Alternative. Long-term O&M simplicity of this option was considered equal to the FWAC/No Action Alternative, as the filter would be designed to allow for regular dredging. The ponding area is usually underwater during events, making observations of poor performance and limited intervention (standard impacts) less likely to occur. This option would help to reduce the probability of having to take major intervention (major impacts).

In summary, Option A helps each action alternative effectively addresses Dam Safety issues, opportunities and objectives, in that it helps lower incremental breach risk to within the USACE Tolerable Risk Guidelines.

5.2.1.5. Future With Alternative Assumptions

Assumptions concerning continuing to properly operate and maintain Zoar Levee & Diversion Dam, execution of maintenance packages to lower incremental risks associated with pump failure, and levee accreditation are also assumed take place in the future for all of the action alternative risk management plans. There is uncertainty in receiving sufficient O&M funds to lower incremental risks associated with pump failure. Until these actions are accomplished, Zoar Levee & Diversion Dam shall continue to have incremental risks of inundation associated with misoperation or component malfunction that are outside of USACE Tolerable Risk Guidelines, regardless of what actions are taken to manage incremental breach risks.

5.2.1.6. Impacts to Affected Environment

While impacts are anticipated to the affected environment, as will be discussed in **Section 5.3**, these impacts should be similar for each action alternative and can be avoided, minimized or mitigated for. Impacts could occur from implementation of operation and maintenance activities forecasted to occur in the FWAC/No Action alternative. The impact potentials would be assessed when these specific actions are being considered and a NEPA document would be prepared for each; and all applicable laws and regulations would be complied with.

5.2.1.7. Societal Concerns

With the exception of the FWAC/No Action Alternative, all alternatives address all societal concerns expressed, including that USACE continue to operate and maintain Zoar Levee & Diversion Dam, Zoar Levee be re-accredited, and Zoar Levee be "repaired".

5.2.2. FWAC/No Action

As detailed in **Chapter 3.0**, the FWAC/No Action Alternative indicates the leveed area's societal value should continue into the future, absent inundation from a breach, pump failure or overtopping. This is because it is assumed Zoar Levee & Diversion Dam would be operated and maintained properly and Zoar Levee would be re-accredited to withstand the base flood.

The FWAC/No Action Alternative also assumes the existing annual probabilities of pump failure would be lowered below the USACE TRLL. Key to this assumption is the execution of $750,000 in maintenance packages.

Therefore, the FWAC/No Action Alternative does address dam safety issues and opportunities to better define and communicate risk, as well as resolve societal concerns associated with removing the project and levee accreditation.

Estimates indicate that the potential for loss of life or economic consequences from a breach prior to overtopping or from a pump failure are low in comparison to other USACE projects. Risk estimates indicate that the FWAC/No Action Alternative would achieve the USACE tolerable risk limit for life safety only. However, the annual probabilities of a breach are forecasted to remain above the USACE TRLL. As the consequences from a breach would not change, incremental inundation risks would remain outside of the USACE Tolerable Risk Guidelines. Therefore, the FWAC/No Action Alternative does not meet the purpose and need for Federal action and fails to address associated Dam Safety issues, opportunities and objectives.

The consequences and severity of impacts on resources if inundation would occur as a result of no action are discussed in **Section 3.4**. In summary, the consequences to social, economic, recreational, and cultural/historic resources and real estate would likely result in permanent and major adverse impacts. The consequences and severity of impacts to HTRW may also be significant if toxic or hazardous materials within the leveed area were released to Dover Dam's impoundment. Impacts to environmental resources would remain unchanged.

5.2.3. Action Alternative 3A Expected Risk Condition

Action Alternative 3A is more effective and complete than the FWAC/No Action, in that it would lower the annual probability of breach and resulting consequences to within the USACE Tolerable Risk Guidelines.

The total annual probability of failure is expected to drop to about a 1 in 50,000 chance, for the "As Intended" outcome. The reduction in total annual probability of failure is smaller for the "Less Favorable" outcome (see **Figure 5-1** below). Both are below the USACE TRLL.

The main factors that contribute to the "As Intended" outcome include the benefits of providing redundancy in the system due to having relief wells and an IEIT in the same locations. While the relief wells are only designed to pool El. 916 feet, the wells are expected to provide some pressure relief for pools up to the levee crest elevation (El. 928.5 feet). Together these measures would help lower the probability of backward erosion piping to begin, or continue (under the levee) if it does initiate.

Factors that indicate a "Less Favorable" outcome include the possibility the relief wells or filters may not be installed properly, or that unknown foundation conditions may result in less pressure reduction in the foundation than expected. There is also the consideration that long-term maintenance of relief wells is very important; if maintenance is not done properly on a regular schedule, it can result in poor relief well performance over the life of the project.

Overall, the project should be more robust and resilient, given the addition of multiple measures (IEIT, new relief wells). The long-term project O&M was considered more complicated than the FWAC/No Action alternative, largely due to concerns about long-term maintenance of relief wells, and the fact there would now be more relief wells to maintain.

A combination of adding redundant features and long-term maintenance issues associated with relief wells increases costs in terms of construction and long-term operations and maintenance, although they do help drop future flood-fighting costs. The installation of relief wells should reduce the probability of having to take limited intervention (standard impacts), because the chance of backward erosion piping to initiate would be reduced. The probability of major intervention (major impacts) is also further lowered by the IEIT.

This alternative also transfers some risk to pump failure, by 0.2 orders of magnitude. However, that risk transfer should not push pump failure risk above the USACE TRLL. Therefore, when compared to the amount of breach risk reduced, the risk transfer is not significant.

In summary, Action Alternative 3A effectively addresses Dam Safety issues, opportunities and objectives, in that it reduces incremental breach risk to within the USACE Tolerable Risk Guidelines. The preliminary estimate of total cost for Action Alternative 3A was $16.99 M.

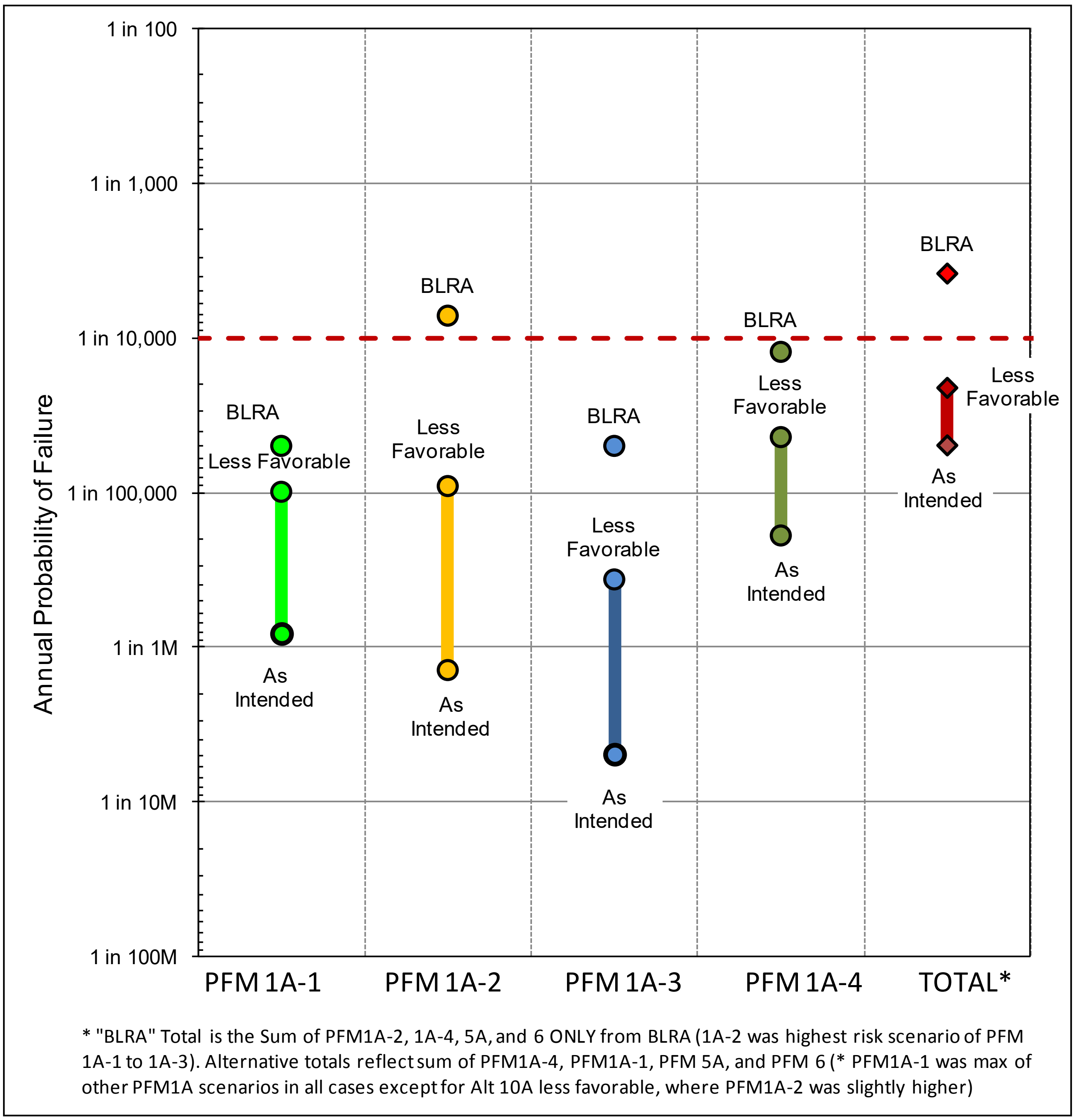

Figure 5-1 Expected risk reduction for Action Alternative 3A.

5.2.4. Action Alternative 4A Expected Risk Condition

Action Alternative 4A is more effective and complete than the FWAC/No Action alternative, in that it would reduce the annual probability of breach and resulting consequences to within the USACE Tolerable Risk Guidelines.

The total annual probability of failure is expected to drop to about a 1 in 50,000 chance, for the "As Intended" outcome. The reduction in total annual probability of failure is smaller for the "Less Favorable "outcome (see **Figure 5-2** below). Both are below the USACE TRLL.

The main factor that contributes to the "As Intended" outcome includes the benefits to providing redundancy in the system due to having relief wells, an IEIT and a weighted filter berm all in the same locations. While the relief wells are only designed to a pool El. 916 feet, the wells are expected to provide some pressure relief for pools up to the levee crest elevation (El. 928.5 feet). Together these measures would help lower the probability of backward erosion piping to begin, or continue (under the levee) if it does initiate.

Factors that indicate a "less favorable" outcome include the possibility the relief wells or filters may not be installed properly, or that unknown foundation conditions may result in less pressure reduction in the foundation than expected. As with Action Alternative 3A, there is also the consideration that long-term maintenance of relief wells is very important; if maintenance is not done properly on a regular schedule, it can result in poor relief well performance over the life of the project.

With Action Alternative 4A, the project would be more robust and resilient than the FWAC/No Action Alternative, given the addition of multiple redundant measures (IEIT, berm, new relief wells). Long-term O&M simplicity was considered lower than FWAC, due to installation of 10 new relief wells. However, this is mitigated for as it was assumed that in the future with Action Alternative 4A, the nine oldest relief wells would be abandoned by filling them with gravel, instead of rehabilitated.

Adding redundant measures increases costs in terms of construction, although Action Alternative 4A does help drop future flood-fighting costs. This installation of relief wells and weighted filter berm should reduce the probability of having to take limited intervention (standard impacts), because the chance of backward erosion piping to initiate would be reduced. The probability of major intervention (major impacts) is also lowered further by the IEIT.

In summary, Action Alternative 4A effectively addresses Dam Safety issues, opportunities and objectives in that it lowers incremental breach risk to within the USACE Tolerable Risk Guidelines. The preliminary total cost estimate for Action Alternative 4A is $17.53 M.

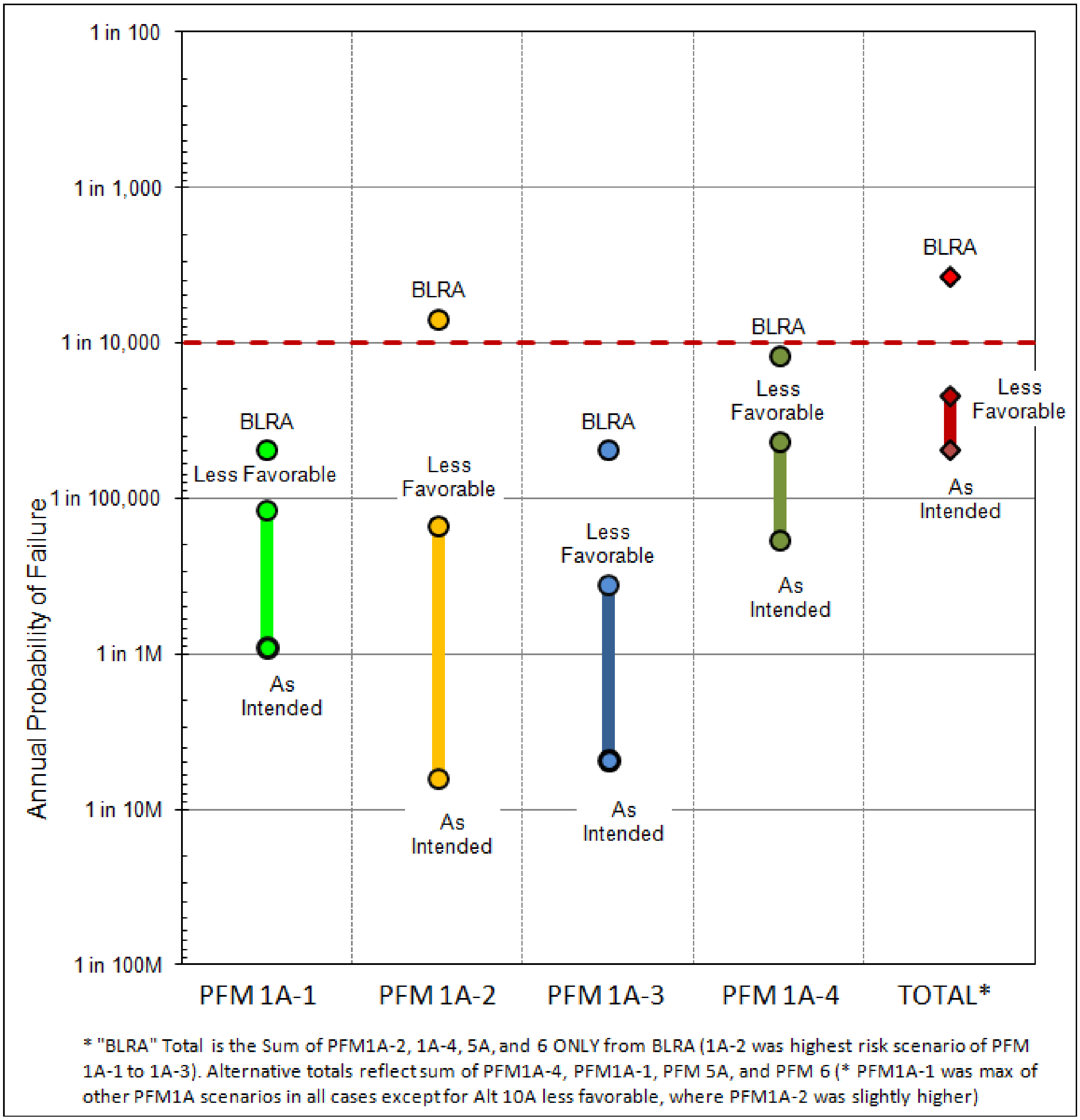

Figure 5-2 Expected risk reduction for Action Alternative 4A.

5.2.5. Action Alternative 6A Expected Risk Condition

Action Alternative 6A is more effective and complete than the FWAC/No Action Alternative, in that it would reduce the annual probability of breach and resulting consequences to within the USACE Tolerable Risk Guidelines.

The total annual probability of failure is expected to drop to about a 1 in 40,000 chance, for the "As Intended" outcome. The reduction in total annual probability of failure is smaller for the "Less Favorable "outcome (see **Figure 5-3** below). Both are below the USACE TRLL.

The main factor that contributed to the "As Intended" outcome was the benefit of having an IEIT across the length of the Ball Field Reach. Factors that indicate a "Less Favorable" outcome include the possibility the IEIT may not be installed and/or designed properly, or uncertainty about the foundation conditions may make it difficult to know if the IEIT intercepts all materials that may be susceptible to backward erosion piping.

With Action Alternative 6A, the project would be more robust and resilient than the FWAC/No Action Alternative. The IEIT would add limited redundancy to the project by supplementing the existing collector's ability to inadvertently serve as an IEIT between 2nd Street (Station 12+00) and the 3rd Base Line (Station 19+00). Long-term O&M simplicity was considered equal to FWAC/No Action Alternative. The IEIT requires no life-cycle maintenance.

As discussed in **Section 4.3.4**, the IEIT installed in the Ball Field Reach, would not reduce water pressures or reduce of the probability of seepage, leading to boils and/or backward erosion piping. It is designed only to arrest any backward erosion piping that continues toward the levee. Therefore, Action Alternative 6A has little effect on reducing any annual flood-fighting costs associated with surveillance and limited intervention (standard impacts); although it does reduce the probability of having to take major intervention (major impacts) on the levee.

In summary, Action Alternative 6A effectively addresses Dam Safety issues, opportunities and objectives, in that it reduces incremental breach risk to within the USACE Tolerable Risk Guidelines. The preliminary total estimate for Action Alternative 6A is $8.01 M.

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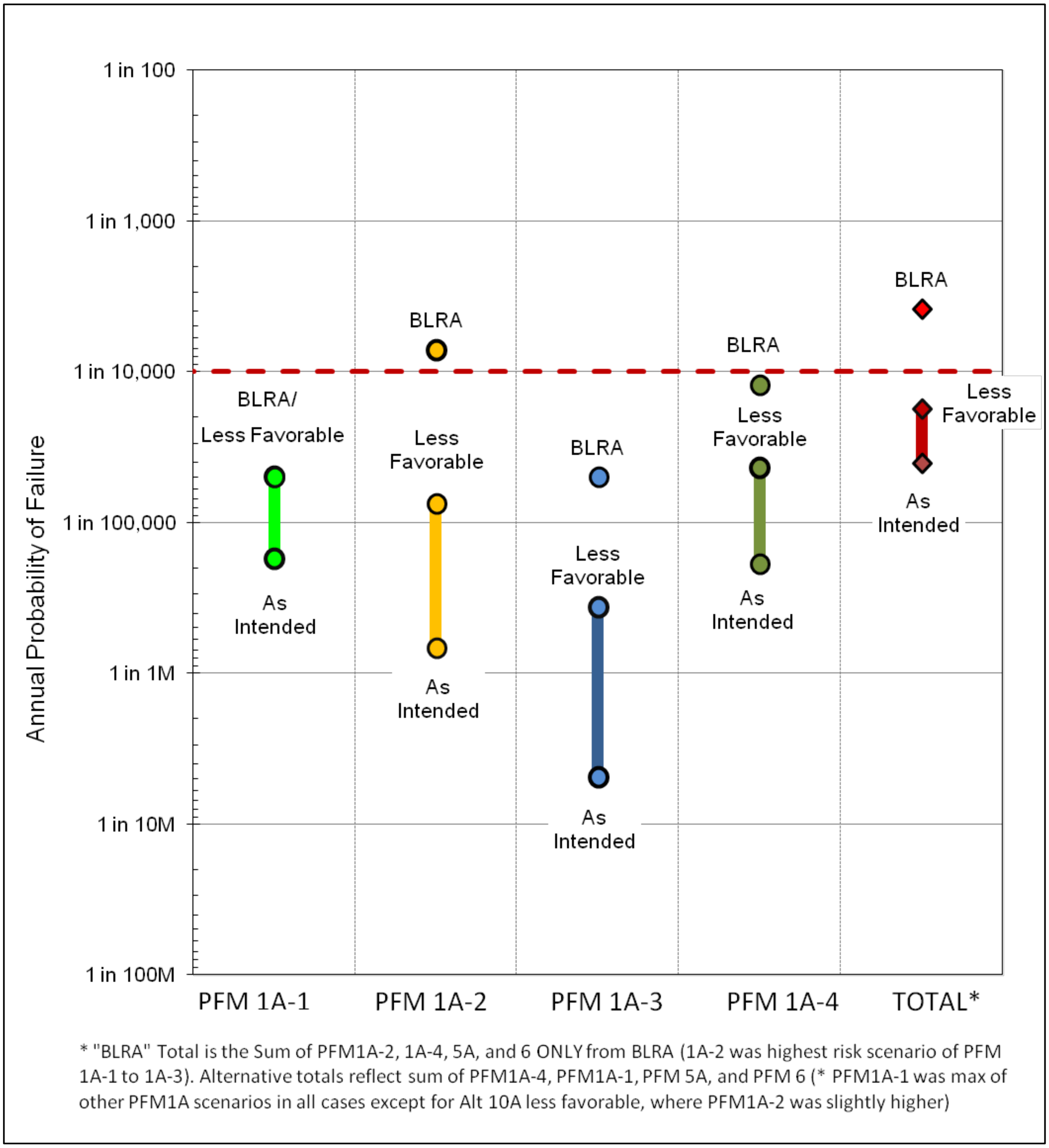

Figure 5-3 Expected risk reduction for Action Alternative 6A

5.2.6. Action Alternative 7A Expected Risk Condition

Action Alternative 7A is more effective than the FWAC/No Action Alternative, in that it would reduce the annual probability of breach and resulting consequences to within the USACE Tolerable Risk Guidelines.

Alternative 7A is more complete than the FWAC/No Action Alternative, because it adds measures to upper and lower reaches of the Ball Field Reach and ponding area, but it leaves one reach unchanged, relying on the collector system to inadvertently act as an IEIT. There is considerable uncertainty concerning this condition. Inherent to Action Alternative 7A is the need to undertake geotechnical investigations to confirm if the existing collector has penetrated the confining layer. In locations where it has not, additional treatments would be required which could potentially increase the magnitude and duration of this alternative significantly.

The total annual probability of failure is expected to drop to about a 1 in 25,000 chance; for the "As Intended" outcome. The reduction in total annual probability of failure is smaller for the "Less Favorable "outcome (see **Figure 5-4** below). Both are below the USACE TRLL.

The factors that contribute to the "As Intended" outcome include the benefits to having an IEIT and small filter berm north of 2nd Street (Sta. 12+00) and a weighted filter berm east of the 3rd Base Line (Sta. 19+00) to reduce the potential for backward erosion piping to start. Together these measures, in combination with existing conditions, treats the probability of backward erosion piping to begin in one locale and treats the probability of backward erosion piping to progress under the levee in another locale.

Factors that indicate a "Less Favorable" outcome include the fact that there is "no action" between these two measures. Instead, the existing toe trench would need to be relied on in this area and there is uncertainty that would act as an IEIT. It is also possible that the existing collector (as an IEIT) or the proposed IEIT may not be installed and/or designed properly, or that about the foundation conditions may make it difficult to know if that IEIT intercepts all materials that may be susceptible to backward erosion piping.

A minor increase in robustness is expected over the FWAC/No Action Alternative. Action Alternative 7A would also be more resilient than the FWAC/No Action Alternative, but add no significant redundancy. Long-term O&M simplicity was considered equal to the FWAC/No Action Alternative. The IEIT and weighted filter berm require no additional life-cycle maintenance.

The IEIT installed in the upper portion of the Ball Field Reach, would not reduce water pressures or reduce of the probability of seepage, leading to boils and/or backward erosion piping. It is designed only to arrest any backward erosion piping that continues toward the levee. Therefore, Action Alternative 7A would not be as effective in decreasing the annual flood-fighting costs associated with surveillance and limited intervention (standard impacts); although it does reduce the probability of having to take major intervention (major impacts) on the levee.

In summary, Action Alternative 7A effectively addresses Dam Safety issues, opportunities and objectives, in that it reduces incremental breach risk to within the USACE Tolerable Risk Guidelines. However, there is significant uncertainty this alternative would not grow in magnitude and duration because of further investigations required during design. Appropriate cost contingencies were added to the preliminary cost estimate. The preliminary total cost estimate for Action Alternative 7A is $9.32 M.

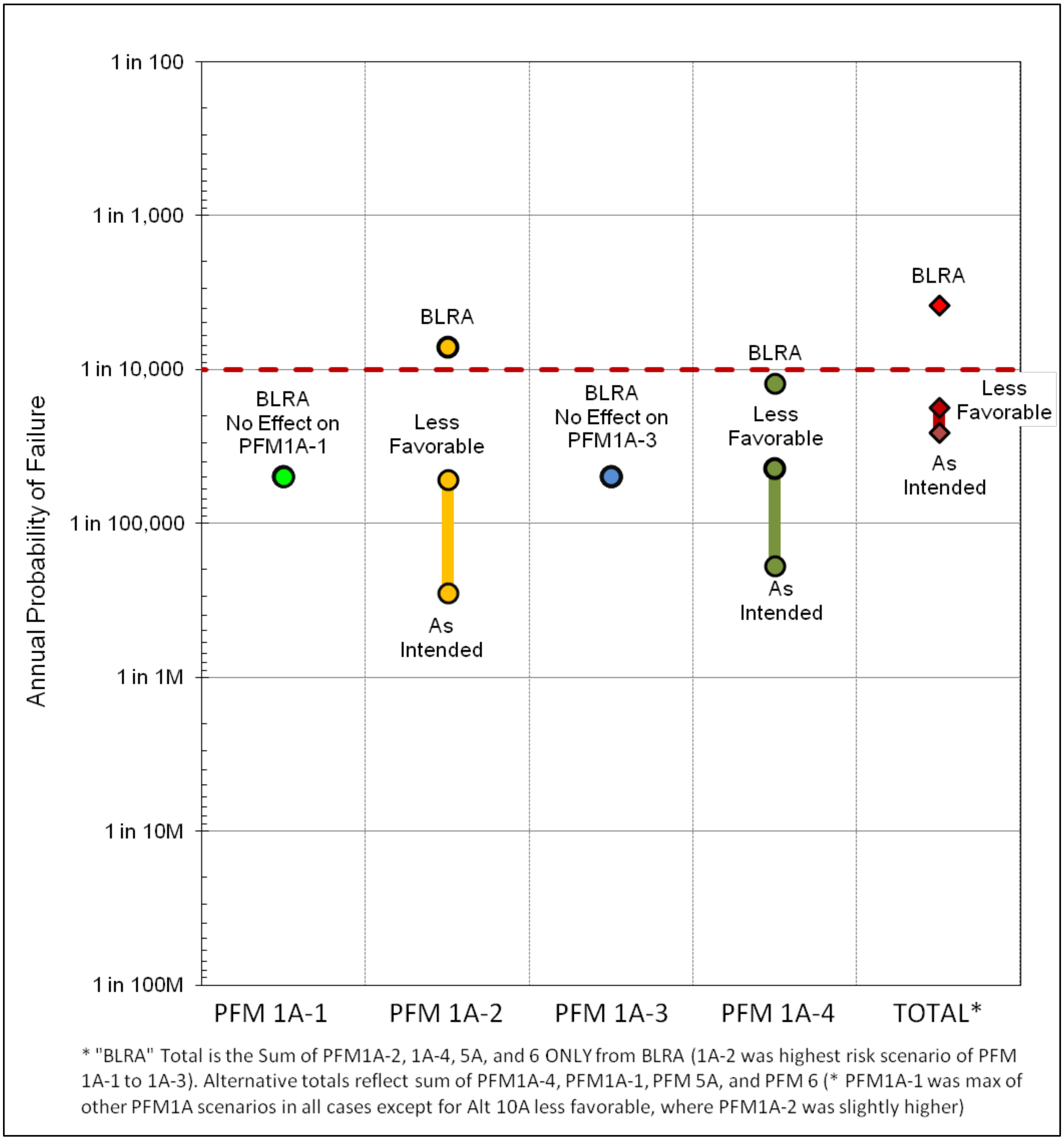

Figure 5-4 Expected risk reduction from Action Alternative 7A

5.2.7. Action Alternative 10A Expected Risk Condition

Action Alternative 10A is more effective and complete than the FWAC/No Action Alternative, in that it would reduce the annual probability of breach and resulting consequences to within the USACE Tolerable Risk Guidelines.

The total annual probability of failure is expected to drop to about a 1 in 50,000 chance, for the "As Intended" outcome. The reduction in total annual probability of failure is smaller for the "Less Favorable "outcome (see **Figure 5-5** below). Both are below the USACE TRLL.

The major factors that contribute to the "As Intended" outcome include the benefits to providing redundancy in the system due to having an IEIT and weighted filter berm across much of the Ball Field Reach of the levee. Together these measures would help lower the probability of backward erosion piping to begin or continue, under the levee, if it does initiate.

Factors that indicate a "Less Favorable" outcome include the possibility the IEIT may not be installed and/or designed properly, or that uncertainty about the foundation conditions may make it difficult to know if that IEIT intercepts all materials that may be susceptible to backward erosion piping.

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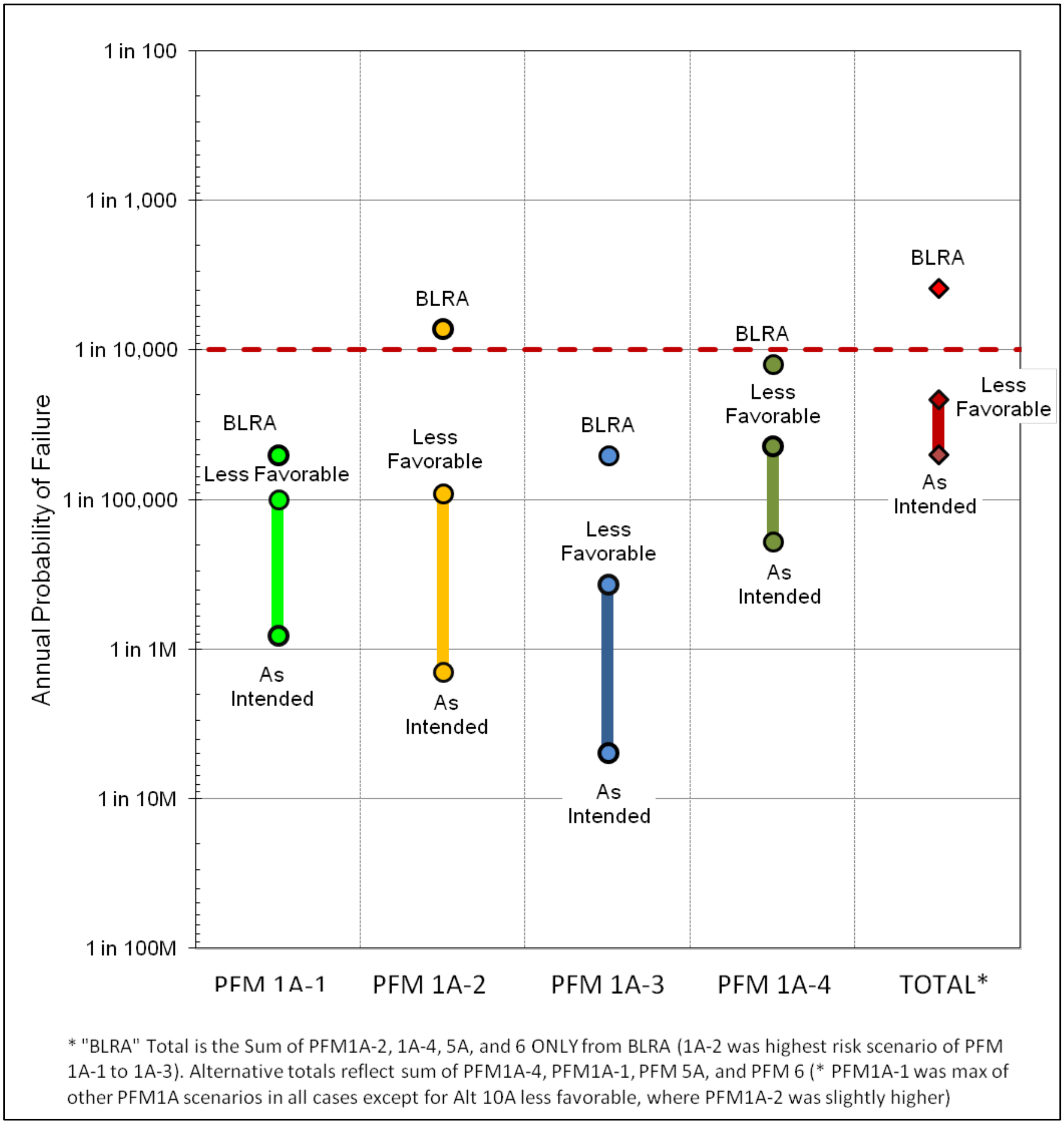

Figure 5-5 Expected risk reduction from Action Alternative 10A.

With Action Alternative 10A, the project would be more robust and resilient than the FWAC/No Action Alternative; given the addition of multiple measures (IEIT, berm). Long-term O&M Simplicity was considered equal to FWAC/No Action Alternative. The IEIT and weighted filter berm require no additional life-cycle maintenance.

A combination of adding redundant measures also help to drop future flood-fighting costs from both standard and major impacts.

In summary, Action Alternative 10A effectively addresses Dam Safety issues, opportunities and objectives in that it reduces incremental breach risk to within the USACE Tolerable Risk Guidelines. The preliminary total estimated cost for Action Alternative 10A is $13.02 M.

5.3. *Benefits and Impacts to the Affected Environment from Action Alternative Risk Management Plans

For the DSMS, given the similar nature of each of the action alternatives in terms of measures, scope, size, construction work limits and final imprint on the landscape, the level of benefits and impacts are comparable for each action alternative. Therefore, the benefits and impacts action alternatives would have on the affected environment will be discussed once.

All construction work, with the exception of borrow activities and the disposal of asphalt, would take place within the identified construction work limits (CWL) which consists of areas previously disturbed by the construction or raising of the levee and/or are currently in mowed grasses or paved areas. All required borrow would be purchased from existing commercial suppliers. Avoiding adverse impacts to any significant resources would be a key factor in selecting a final borrow site. All asphalt will be disposed of in accordance within all pertinent laws and regulations. Construction work is estimated to take approximately 1.5 to 2 years.

5.3.1. Zoar Village (Social, Economic, Recreational and Cultural/Historical Resources)

Given the symbiosis that exists between Zoar Village's social and economic viability, the heritage tourism and recreation, and historical and cultural value, it is understood that impacts to one cannot be separated from the others. Therefore, impacts to social, economic, recreational and cultural/historical resources were evaluated in an integrated manner.

Each action alternative reduces the annual probability of breach, and therefore has positive effects for Zoar Village. Each action alternative is expected to lower annual probability of breach below USACE TRLL within a range of variability of one another that is not significant. Therefore, one action alternative is unlikely to have more or less positive effects to the continued health and survival of Zoar Village.

Construction work limits for all action alternatives avoid physically altering any historic building or structure and are located within areas most likely disturbed by previous construction activities. However, the potential to directly and indirectly affect social, economic, recreational and cultural/historical resources still exists.

Zoar Levee & Diversion Dam is a contributing element to the MUR and is also recommended as a contributing element to a proposed 2013 NRHP boundary revision. Preliminary analysis indicates that proposed action alternatives are likely to have no adverse effect on Zoar Levee &

Diversion Dam. However, as discussed in **Section 5.3.1.3**, effects to historic properties are being taken into account by the execution of a programmatic agreement (**Appendix D – Addendum 2**).

As discussed in **Section 3.4**, the State of Ohio and Zoar Village have real estate out-grants on Federal land and have established parking facilities and a Little League Ball Field. It has been determined that for any action alternative, there is potential for damage to these facilities.

As discussed in **Section 5.3.3**, parking areas licensed to the State of Ohio were out-granted with a clear understanding that this license can be revoked at any time for convenience of the Government. Therefore, the existing condition for the licensed area is that it could be taken at anytime without any compensation or mitigation.

Alternatively, the Park and Recreation Lease granted to Zoar Village does not allow removal of the Lessee's property by the Government unless the Lease is revoked. Under the terms of the lease, the Government may revoke the lease only for non-compliance of the terms contained in the lease. Notwithstanding, the lease agreement sets up a clear understanding that the land may be utilized at the convenience of the Government for project purposes without mitigation. However, compensation could be provided to Zoar Village for any of their property damaged due to project construction within the leased area.

Following construction, the State of Ohio can apply to reestablish an out-grant if they wish and Zoar Village could propose re-establishment of lost features and/or the addition of new features within their Leased area. To not impact the expected risk condition from action alternatives, the location and extent of parking or other features would have to be limited. In addition, asphalt or concrete pavement would not be permitted because it could affect the expected risk condition by confining water pressures, concentrating seepage, and making detection of performance issues more difficult.

Following construction activities, Huntington District shall consult as required, using the programmatic procedures in **Section 5.3.1.3,** to attempt to re-establish an aesthetic environment similar to what existed prior to construction as to avoid or minimize any indirect adverse effects to the historic character of Zoar Village. During this consultation, Huntington District would consider different landscape measures along the surface, including grasses and/or gravel that could allow for the re-establishment of parking.

In additional to the utilization of the out-granted areas and the potential removal of the improvements, a small (~0.08 acre) parking lot owned by the State of Ohio (Parking Area A on **Figure 3-12**) would have to be acquired and demolished for implementation of the action alternatives. The State of Ohio would be compensated for this land and improvements. This parking lot provides for approximately 12 parking spaces, which is not considered significant given other parking facilities exist to accommodate residents and visitors. The State of Ohio could feasibly utilize land they currently own to establish additional parking. In addition, during major festivals, additional parking is provided in a fallow field located just north of town for visitors.

Therefore, there are no anticipated significant impacts associated with the potential damage to existing out-granted parking facilities or purchase of a small amount of other parking facilities, to social, economic, recreational or cultural/historical resources.

To help refine what other impacts action alternatives would have on Zoar Village, a planning charrette was held with Zoar Village's leaders and stakeholders to build a risk register of potential impacts (included in **Appendix D – Addendum 2**). In summary, this Effects Risk Register identified two categories of impacts of most concern:

1. Impacts during construction; and
2. Impacts resulting from construction.

5.3.1.1. Construction Impacts to Social, Economic, Recreational & Cultural/Historical Resources

In summary, the concerns about impacts during construction generally fell with these categories.

- Active construction work which may temporarily reduce the desirability of visiting or otherwise recreating in Zoar Village on a daily basis as well as during major festivals.
- Temporarily increasing construction and truck traffic.
- Limiting access to all but residents on 1st street west of Route 212 and temporary closure of 1st street, west of Park Street.
- Temporarily limiting access to all but residents on 5th street west of Route 212.
- Temporarily increasing dust, sediment erosion that could damage buildings, historic properties or reduce tourism.
- Temporarily increasing light and noise pollution
- Temporarily increasing vibration due to construction equipment that might cause structural damage.
- Permanent impacts to potential archeological resources.

5.3.1.2. Post-Construction Impacts to Social, Economic, Recreational & Cultural/Historical Resources

In summary, post-construction concerns include the following categories.

- Altering or reducing the visual effectiveness of the passive barrier between the historic site and levee.
- Indirectly altering the integrity of the historic site.

5.3.1.3. Avoidance, Minimization & Mitigation for Impacts to Social, Economic, Recreational & Cultural/Historical Resources

Most of the construction impacts would be temporary in nature and similar to those experienced during recent implementation of IRRMs, and less severe than those experienced during the construction and subsequent raising of the levee. Further, many of the potential impacts identified in Effects Risk Register during construction, can be avoided or further minimized by establishing protocols and best management practices. Included in each action alternative were features designed to reduce the impacts to social and recreational life in Zoar Village during construction, making them not only temporary but minor in nature. For example, the following were included:

- Appropriately securing the construction site;
- Employing best management practices to keep pedestrian and vehicular traffic safe during construction;
- Restricting work to daylight hours and including best management practices to minimize temporary changes in noise levels and light pollution;
- Establishing no-idle zones to minimize noise levels;
- Limiting construction traffic to 1st and 5th streets to stay out of the main part of the village and reduce noise, dust and safety hazards;
- Using appropriate erosion and sediment control, regular street washing, covering all loads of soil and gravels to reduce dust impacts;
- Flushing out storm sewer systems following construction to the ponding area;
- Not allowing construction on Sundays, and only on Saturdays if critical;
- Sequencing construction work to partially leave parking lots open;
- Shutting down construction and marshalling equipment off site during major festivals (i.e. Harvest Fest, Civil War Days, Christmas in Zoar);
- Working with Zoar Village and its stakeholders to design outreach efforts and interpretative displays making clear that Zoar Village is open during construction;
- Conducting pre-construction structural assessment and vibration studies to evaluate the existing condition and determine appropriate levels of vibration monitoring during construction;
- Conducting pre-construction archeological surveys to determine if any significant archeological sites are located within the area of potential effects;
- Designing landscape restoration plans to be sympathetic to the existing condition.

A complete list of best management practices can be found in **Appendix D – Addendum 2**.

It was also determined that until the action alternative was selected and subjected to more detailed design, not all impacts and effects to specific social, economic, recreational and cultural/historical resources could be entirely understood in terms of likelihood and magnitude.

With this in mind, and in accordance with Section 106 of the NHPA and 36 CFR 800, the Huntington District has consulted with the OHPO, as well as other consulting parties (Section 106 Consulting Parties), for the purpose of taking into account the potential effects of the undertaking on historic properties. The result of this consultation has been the development of a Programmatic Agreement, in accordance with 36 CFR 800.14(b)(1)(ii) "Use of programmatic agreements", and Paragraph C-4.d(5)(C) of Appendix C "Environmental Evaluation and Compliance" of ER 1105-2-100 "USACE Planning Guidance Notebook", to address potential effects that cannot be fully determined prior to approval of the DSMR (**Appendix D – Addendum 2**).

Huntington District shall ensure the stipulations set forth in the Programmatic Agreement are carried out to resolve its obligations under Section 106. This Programmatic Agreement outlines specific efforts that will be accomplished during the Planning, Engineering and Design (PED) and construction of the RMP/PAA to better identify and manage effects to historic properties, but also social, economic and recreational concerns, given their symbiotic relationship. This Programmatic Agreement includes all of the best management practices and avoidance and minimization strategies discussed above.

With the advent of this Programmatic Agreement, any additional social, economic, recreational, and cultural/historical impacts or adverse effects related to the historical integrity and significant character-defining features of Zoar Village that are identified from any of the action alternative risk management plans shall be managed to avoid, minimize or mitigate those impacts and/or effects appropriately.

This Programmatic Agreement and any resulting effects management options agreed upon due to the implementation of its stipulations, shall be appended to any PED and/or construction documents and contracts associated with the design and implementation of the approved undertaking. Appropriate contingencies were applied to each action alternative cost to cover these efforts.

In conclusion, positive impacts to social, economic, recreational, and cultural/historical resources would be experienced by continuing to invest in Zoar Levee's overall performance by reducing the potential it would breach.

Impacts experienced during construction would mostly both temporary and minor in nature. These impacts would be further minimized by best management practices and implementation of stipulations in the Programmatic Agreement.

While it is anticipated that most of the areas proposed for disturbance by action alternatives have already been disturbed, further efforts to identify archeological resources will be undertaken prior to construction in accordance with the Programmatic Agreement. If significant archeological resources are discovered, strategies to either avoid or mitigate for any impacts to archeological resources will be developed in consultation required by the Programmatic Agreement.

Long-term impacts associated with altering or reducing the visual effectiveness of the passive barrier between the historic site and the levee or altering the integrity of the historic site can be minimized by including project features that would incorporate appropriate visual barriers or other design elements meant to reduce loss of any integrity to the historic site. The nature and extent of these project features would be designed during consultation required by the Programmatic Agreement.

5.3.2. HTRW

Based upon the results of the Phase I ESA, no impacts from HTRW are anticipated from implementation of any of the action alternative risk management plans. While potential HTRW concerns were raised by the Phase I ESA, none of the potential locations for HTRW are located within the construction work limits for any of the action alternatives.

5.3.3. Real Estate

The action alternatives would require the acquisition of additional land in order to construct, operate, and maintain the project. Between 0.18 and 1.14 acres of land held by 3 to 4 owners would be required by the action alternatives. Only portions of parcels of land would be required. Acquisition of structures or buildings would not be necessary. Appraisals would be completed in order to determine the fair market value of the required land and this amount would be offered to the land owners.

Each action alternative also has the potential to require relocation of public utilities/facilities currently located on Federal land, including: gas lines, electric poles, telephone lines and a storm sewer grate and line. Preliminary determinations indicate that the owners, except for an existing gas line, do not have a compensable interest in the utilities/facilities located on Government owned lands and, therefore, they would have to be relocated at the expense of the owner. The gas line would be relocated at the expense of the Government under a public facilities relocation agreement between the owner and the Government.

Action alternatives also include closing and utilizing portions of 1st and 5th Streets. Since it is determined that the Village of Zoar has a compensable interest for the Streets, a relocation contract may be utilized for any adjustments and repairs needed, and for the temporary closure and traffic restrictions required during construction.

Regarding the out-grants to the State of Ohio and Zoar Village, discussed in Section **5.3.1**., it is anticipated that the agreements would be terminated or modified. A discussion of the Preliminary Attorney's Opinion of Compensability for these facilities and any estimated associated real estate cost is included in the Real Estate Plan in **Appendix J**.

Given the small size of real estate required for implementation of any of the action alternatives, the impacts are considered minor in nature.

5.3.4. Environmental Resources

Each action alternative risk management plan includes Option A, which would involve impacts to the Pump Station Wetland, which is an approximate 0.3 acre herbaceous wetland. The wetland sits within the ponding area. The ponding area was excavated in the 1950s to provide ponding for the Pump Station. The ponding area is periodically (~10 years) dredged to maintain its operability. (However, the area has not been dredged for several years and currently is a herbaceous wetland.) This condition would continue in all the action alternatives.

No impacts to streams are proposed by the action alternatives. Impacts to regulated waters (discharge of dredged and/or fill material) would require a Section 401 of the Clean Water Act, Water Quality Certification. While USACE does not issue Clean Water Act permits (under Section 404) to itself, Huntington District conducted an independent analysis to assure compliance with the Clean Water Act. The action alternatives would require the discharge of dredged and/or fill material into the Pump Station Wetland (which is a low to moderately low quality wetland) and result in elimination of this wetland area This discharge of dredged and/or fill material would be regulated under the Clean Water Act. In order to obtain a Water Quality Certification from the State 401 Agency, Ohio Environmental Protection Agency (OEPA), compensatory mitigation would be required.

The discharge of dredged and/or fill material would meet the terms and conditions of OEPA's general water quality certification under Nationwide Permit number 3 for maintenance activities. The Nationwide Permits are valid for a period of five years and are currently valid until March 2017, at which time the Nationwide Permits would be modified/re-issued, etc. It is anticipated the water quality certification would be re-issued with similar terms and conditions when the Nationwide Permits are renewed/reissued. The mitigation plan as proposed is in compliance with OEPA's State Standards for wetland impacts of this nature.

As more than 1 acre of ground disturbance is included in each action alternative, Section 402 of the Clean Water Act Permit (National Pollution Discharge Elimination System) would be required.

In regards to the Clear Air Act, the most recent data on U.S. Environmental Protection Agency's Green Book Database, Tuscarawas County is in attainment with Primary National Ambient Air Quality Standards (NAAQS) for all six (6) criteria pollutants. All action alternatives would require the use of fossil-fuel burning equipment, including but not limited to excavators, dump trucks, and bulldozers. Preparation of the site for construction, and installation of action alternatives would result in the majority of air emissions. Site work is estimated to take approximately 1.5 years to complete. Temporary impacts may include fugitive dust, petroleum product odors, and exhaust fumes.

Given the condition of the construction work limits, minimal impacts to terrestrial habitat may occur due to implementation of any action alternative. Each action alternative includes the likelihood of some limited tree-clearing; including the removal of trees in the area in the out-granted portion of the Ball Field Reach and from residential backyards. If trees cannot be avoided and must be cut, seasonal clearing would occur and any tree clearing shall only occur from October 1 through March 31. If tree clearing is required outside this window, re-coordiantion with the U.S. Fish and Wildlife Service (USFWS) would be initiated and a mist net survey may be required. Concurrence from the USFWS has been obtained and consultation has been completed, provided the work occurs as described.

5.3.4.1. Avoidance, Minimization & Mitigation for Impacts to Environmental Resources

Significant stream and wetland resources would be avoided with all the action alternatives. While USACE does not issue Clean Water Act permits to itself, Huntington District conducted an independent analysis to assure compliance with the Clean Water Act. To further minimize impacts to the Pump Station Wetland, USACE determined that the preferred mitigation plan for impacts to the would be accomplished by purchase of approximately 0.5 acre of wetland credit at an approved Mitigation Bank or In-Lieu Fee Site within the service area in the Muskingum watershed. It has been verified that wetland credits are available through mitigation banks or in lieu fee programs and appropriate costs have been included within each action alternative.

Concerning Section 401 of the Clean Water Act, prior to construction within waters, including wetlands, a Water Quality Certification would be obtained from Ohio Environmental Protection Agency (OEPA). Impacts to the Pump Station Wetland qualify for OEPA's general water quality certification for maintenance activities which is valid until March 2017. It is anticipated the water quality certification would be re-issued with similar terms and conditions. The mitigation plan as proposed above is in compliance with OEPA's State Standards for wetland impacts of this nature.

Concerning Section 402 of the Clean Water Act, best management practices would be defined in a storm water pollution prevention plan and would be implemented throughout construction so that impacts are minimal.

The required Section 401 and 402 authorizations would be obtained prior to initiation of construction.

Concerning the Clean Air Act, impacts associated with construction would be insignificant because equipment and construction techniques would comply with applicable local, state, and Federal regulation and would be short-term in nature.

During construction, measures would be taken to ensure compliance with Federal and state regulations regarding fugitive dust control and open burning. Fugitive dust must be kept at a minimum. Measures, such as application of water to suppress dust and the washing down of construction vehicles and paved roadways immediately adjacent to the construction site would be implemented as necessary. All land clearing debris would be disposed of in an approved manner.

It is Huntington District's determination the proposed alternatives may affect, but are not likely to adversely affect, the Indiana bat and northern long-eared bat. If trees cannot be avoided and must be cut, seasonal clearing would occur and any tree clearing shall only occur from October 1 through March 31. If trees cannot be avoided and must be cut, seasonal clearing would occur and any tree clearing shall only occur from October 1 through March 31. If tree clearing is required outside this window, re-coordiantion with the U.S. Fish and Wildlife Service (USFWS) would be initiated and a mist net survey may be required. Concurrence from the USFWS has been obtained and consultation has been completed, provided the work occurs as described.

Appropriate contingencies were applied to each action alternative cost to cover these efforts. Given the similarities of each of the action alternatives, the associated effort was considered nearly identical for each one. Therefore, for evaluative purposes, no one action alternative had clearly more or less potentials to impact to environmental resources.

Overall, impacts to environmental resources within the construction work limits would be minor and temporary in nature since the proposed construction would not impact streams, include impacts to one small wetland (0.3 acre Pump Station Wetland), involve minimal tree clearing and implementation of sediment and erosion control features.

5.3.5. Other Impacts

In terms of prime and unique farmland, none of the actions alternatives should impact any agricultural land.

No environmental justice impacts in minority and/or low income populations are expected.

As discussed in **Section 3.3.2.5**, much of the leveed area is currently located in a flood hazard zone, or within the base flood plain, due to the de-accreditation of Zoar Levee. However, USACE has a reasonable assurance in Zoar Levee's ability to withstand the base flood. At the request of Zoar Village, and on their behalf, USACE is preparing a positive LSE to send to FEMA and it is assumed FEMA will re-accredit the levee, removing the leveed area from the base flood plain.

All proposed action alternatives fall within the landward side of the levee. By the time they are implemented, this area will no longer be within the base flood plain. Further, none of the action alternatives will impact, or induce further development of the base flood plain outside of the levee. This area is subject to flowage easement by the Federal government which restricts development to allow for impoundment of waters behind Dover Dam. While action alternatives would further reduce flood hazards to the leveed area, they are unlikely to encourage further development. As discussed in **Section 3.3.2.7**, Zoar Village is anticipated to maintain a near static condition in the future because maintaining historical integrity is required for its continued survival. Therefore, all of the action alternatives would be in compliance with Executive Order 11988 for Floodplain Management.

5.3.6. Cumulative Impacts

Huntington District must consider the cumulative effects the action alternatives may have to the environment as stipulated in NEPA. Cumulative effects are "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions". Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR Part 1508.7 CEQ Regulations).

The cumulative effects analysis is based on the potential effects of the action alternatives when added to similar impacts from other projects in the region. An inherent part of the cumulative effects analysis is the uncertainty surrounding actions that have not yet been fully developed. The CEQ regulations provide for the inclusion of uncertainties in the analysis and states that "when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment.....and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking" (40 CFR 1502.22).

Direct and indirect effects resulting from the implementation of the actions alternatives have been outlined above. The period of analysis for the DSMS is 50 years and is considered a temporal boundary for this cumulative impacts analysis. The study area defined for affected area baseline studies reported in **Section 3.2.4** is the appropriate boundary for considering most cumulative impacts. In scoping this cumulative effects analysis, consideration was given to the following resources: aquatic, social, economic, recreational and cultural/historic resources.

Given the limited effects to aquatic resources identified and the lack of potential for development within the area, it has been determined that the potential cumulative effects are insignificant.

As described in **Section 5.3.1.3** direct and indirect effects may occur from implementation of an action alternative to social, economic, recreational and cultural/historical resources, and they would be addressed by the programmatic agreement through avoidance, minimization or mitigation. In addition, the most significant consequence from incremental risk is damage or destruction to Zoar Village because of the significant societal value it provides. Zoar Village is the principle beneficiary of Zoar Levee. The action alternatives would therefore, result in overall benefit to social, recreational and cultural/historical resources by reducing the probability of levee breach and associated consequences. Given that adverse effects can be avoided, minimized, or mitigated for and the overall impact from an action would be beneficial, these actions should not contribute to significant cumulative adverse effects.

5.4. Summary of Evaluation of Alternative Risk Management Plans

With the exception of the FWAC/No Action Alternative, each of the alternative risk management plans meet the purpose and need for Federal action by reducing incremental risks associated with breach from backward erosion piping and, as a result, lowering the probability of consequences to occur.

Each alternative is acceptable to applicable law, regulation and policy. While the efficiency of each action alternative varies, they do not provide net benefits. With the clear exception of Alternative 7A, each action alternative has relatively similar completeness, when compared to the FWAC/No Action Alternative. Each action alternative targets specific locations with specific treatments to either lower the probability of backward erosion piping from starting or continuing; although some action alternatives incorporated more redundancy than others. Only Alternative 3A significantly increases future O&M costs and complexity associated with additional relief wells. None of the action alternatives eliminate future potential flood-fighting costs, although all reduced them. Those alternatives that included measures that helped reduce the probability of backward erosion piping beginning were generally more effective at reducing potential future flood-fighting costs.

Each of the action alternatives rely on the execution of maintenance packages to rehabilitate the pumps and repair the diversion channel culvert to lower incremental risks associated with pump inundation.

In terms of time, inundation risk would remain outside of the USACE Tolerable Risk Guidelines until incremental risks from breach and pump inundation are addressed through future maintenance packages.

Impacts to the affected environment are anticipated from each alternative, although given the similarities no significant differences exist between the alternative impacts. Further strategies and appropriate contingencies have been developed to avoid, minimize or mitigate for any impacts. With the exception of the FWAC/No Action Alternative, each alternative also resolves all societal concerns.

These evaluation factors were then used to compare alternatives against each other to identify the risk management plan that best meets the purpose and need for Federal action in a manner that supports the expeditious and cost effective reduction of risk.

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6.0 COMPARISON OF ALTERNATIVES AND SELECTION OF THE PREFERRED ACTION RISK MANAGEMENT PLAN

In this chapter, alternatives are compared against each other, emphasizing those factors that clearly distinguish each alternative to help rank plans in terms of their ability to meet the purpose and need for Federal action and the Dam Safety objectives. The primary evaluation factors used for selecting a RMP/PAA for the DSMS are the annual probability of failure in relationship to the USACE TRLL and cost-effectiveness. Considerations are also given to other pertinent and differentiating factors.

6.1. Comparison of Alternatives

Evaluation factors are displayed for comparison in **Table 6-1**, with a color scheme substituted for the elicited numbers. Only those evaluation factors that varied between the alternatives (except cost) are displayed. All but the FWAC/No Action Alternative lower the annual probability of breach below USACE TRLL. As shown graphically in **Figure 6-1**, when the annual probability for the total of all the PFM 1A failure modes is compared, this risk reduction is similar, and all the action alternatives meet the study objectives. The FWAC/No Action Alternative clearly does not compare well against the action alternatives.

Table 6-1 Comparison of Differentiating Evaluation Factors

Factors	FWAC	3A	4A	6A	7A	10A
Effectiveness		++	++	+	+	++
Robustness	-	+	+	++	+	++
Redundancy		+	+	-		+
Resiliency	-	++	++	++	++	++
Completeness		+	++	+	-	+
Constructability	NA	+	+	++	++	+

LEGEND			
++	+	-	

Table 6-1 helps to highlight key differentiating factors. This shows that Action Alternatives 6A and 7A were considered to have low redundancy. While not demonstrated above, Action Alternative 4A had the most redundancy. Action Alternative 7A was considered low in completeness, whereas Action Alternative 4A was the most complete. In addition, those action alternatives with relief wells, 3A and 4A, were considered to have more constructability issues when compared to the others. When considering the overall effectiveness of the action alternatives, 7A was seen as the least effective, with 3A, 4A and 10A the most effective.

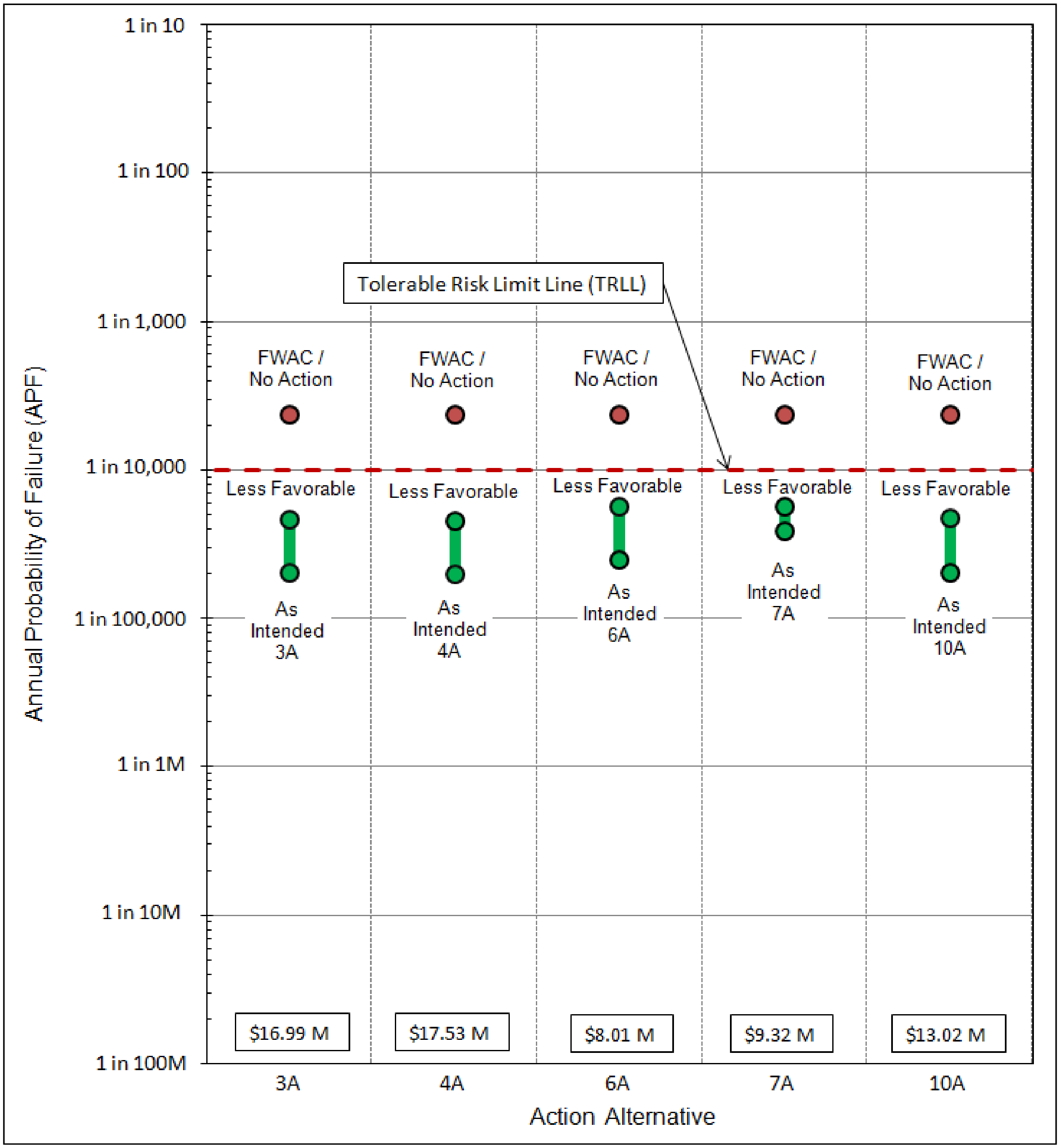

Figure 6-1 Comparison of total levee risk reduction for final array of action alternatives (Sum of PFM 1A-4, the highest of PFM 1A-1 through PFM 1A-3, PFM 5A and PFM 6).

6.1.1. Comparison of Future O&M Considerations

Another differentiator in comparing action alternatives was future O&M costs. As demonstrated in **Table 6-2**, the biggest differences were costs from standard flood-fighting. In general, those alternatives with measures designed to reduce the probability of backward erosion piping to start, also lower future standard impact flood-fighting costs significantly. Alternatives 6A and 7A on the other hand do not reduce the standard flood-fighting costs. Alternative 3A, which substantially increases the number of relief wells at the project, also has the highest annualized cost associated with well maintenance and rehabilitation, and the highest O&M complexity.

Table 6-2 Comparison of O&M costs for final array of action alternatives

O&M Line Item	Annualized Cost By Alternative					
	FWAC	3A	4A	6A	7A	10A
Standard Annual O&M	*$49,380*	*$49,380*	*$49,380*	*$49,380*	*$49,380*	*$49,380*
Repair of Electrical/Mechanical Equipment	*$14,848*	*$14,848*	*$14,848*	*$14,848*	*$14,848*	*$14,848*
Submersible Electric Gate Operator	*$140*	*$140*	*$140*	*$140*	*$140*	*$140*
Flood Fighting – Standard	**$26,175**	**$17,240**	**$13,145**	**$26,175**	**$26,175**	**$18,960**
Flood Fighting – Major	**$4,324**	**$715**	**$357**	**$715**	**$768**	**$357**
Channel Work	*$7,800*	*$7,800*	*$7,800*	*$7,800*	*$7,800*	*$7,800*
Rehab 2 Pumps	*$7,200*	*$7,200*	*$7,200*	*$7,200*	*$7,200*	*$7,200*
Video of Collector System	*$0*	*$243*	*$243*	*$0*	*$0*	*$0*
Video of Existing Toe Drain	*$765*	*$765*	*$765*	*$765*	*$765*	*$765*
Well Maintenance	**$7,000**	**$12,500**	**$7,500**	**$7,000**	**$7,000**	**$7,000**
Well Abandonment	**$0**	**$200**	**$200**	**$0**	**$0**	**$0**
Relief Well Rehab	**$14,000**	**$25,000**	**$15,000**	**$14,000**	**$14,000**	**$14,000**
Annualized Totals	$131,632	$136,031	$116,578	$128,023	$128,076	$120,450

6.1.2. Comparison of Cost and Efficiency

None of the action alternatives generate net benefits, although Zoar Levee & Division Dam was not formulated to accrue economic growth. In terms of costs, those alternatives that incorporated more redundancy and reduce the probability of backward erosion piping to start as well as continue back toward the levee, cost more to construct. Alternative 6A is the least-costly alternative. See **Table 6-3**.

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Table 6-3 Comparison of preliminary total cost estimate and annualized net benefits for final array of action alternatives

ACTION ALT	BALL FIELD OPTIONS (PFM1A-2)	PONDING AREA OPTIONS (PFM1A-4)	PRELIMINARY TOTAL COST ESTIMATE	ANNUALIZED NET BENEFITS
3A	Relief Wells & IEIT	Filter	$16.99 M	*-$966 K*
4A	Partial Weighted Filter Berm & Partial Relief Wells & IEIT	Filter	$17.53 M	*-$905 K*
6A	IEIT Trench	Filter	$8.01 M	*-$488 K*
7A	Partial Length IEIT & Partial Weighted Filter Berm & No Action	Filter	$9.32 M	*-$547 K*
10A	IEIT & Partial Weighted Filter Berm	Filter	$13.02 M	*-$705 K*
*Includes Real Estate, Planning & Engineering During Design, Mitigation, Construction, Supervision & Administration, and Engineering During Construction (FY14 Price Level).				

6.1.3. *Comparison of Benefits & Impacts to the Affected Environment

As discussed in **Section 5.3**, given the similar nature of the each of the action alternatives in terms of measures, scope, size, construction work limits, and final imprint on the landscape, the level of benefits and impacts are functionally identical for each alternative. Therefore, for comparison sake, benefits and impacts to the affected environment did not play a major role in identifying the RMP/PAA.

6.1.4. Ranking of Alternative Risk Management Plans

In summary, each of the action alternatives support the purpose and need for Federal action, in that they lower annual probability of breach below the USACE TRLL. As previously discussed, operational changes and execution of maintenance packages would be utilized to lower the annual probability of inundation due to misoperation or component malfunction below the USACE TRLL.

The alternative risk management plans were ranked, as shown in **Table 6-4**. The FWAC/No Action Alternative ranks last, given it does not meet the purpose and need for Federal action or Dam Safety objectives. Alternative 6A was ranked first as it supported the most cost effective reduction of risk and did not pose any more or less significant impacts to the human environment.

Table 6-4 Ranking of final array of action alternatives

Alternative	Rank	Reasoning
FWAC/NO Action	6	Fails purpose & need and meet risk management objectives.
3A	4	Most effective, best reduction in risk. Good robustness, most costly, and low efficiency.
4A	3	Most effective, best reduction in risk and similar to 3A with more redundancy with similar cost to 3A. Still significantly more expensive when compared to other alternatives (6A & 10A)
6A	**1**	**Lowest cost, most efficient plan to meet risk management objective. Good effectiveness and reduction of risk. Good robustness. Little redundancy.**
7A	5	Least efficient, effective, and complete.
10A	2	Most effective, best reduction in risk & more robust than 6A. Good redundancy. Same risk reduction as 3A & 4A for less cost.

6.2. Selected Risk Management Plan/Preferred Action Alternative (RMP/PAA)

The single largest distinction among the final array of action alternatives was the cost. None of the action alternatives create positive economic benefits, although as discussed herein, Zoar Levee & Diversion Dam was not authorized to provide traditional economic benefits. With that understanding, when considering the efficiency of the action alternatives, the least-costly alternative was Action Alternative 6A.

Therefore, as Action Alternative 6A meets the purpose and need for Federal action in a manner that supports the expeditious and cost effective reduction of risk, it has been identified as the selected Risk Management Plan/Preferred Action Alternative (RMP/PAA).

6.2.1. Summary of RMP/PAA

The RMP/PAA consists of an IEIT and small weighted filter berm along the Ball Field Reach and a reverse filter in the ponding area. The IEIT is intended to arrest backward erosion piping that may have started, and in this way designed to reduce the annual probability of failure for PFM 1A-2. The small weighted filter berm is required to prevent the initiation of backward erosion priping in the area between the landward levee toe and the IEIT. The reverse filter is intended to prevent soil erosion from starting, lowering the annual probability of failure for PFM 1A-4.

Figure 6-2 is a plan view displaying the features included in the RMP/PAA, as well as the planned disposal areas, access routes, and work limits. **Figure 6-3** shows a cross section of the levee in the Ball Field Reach with the plan in place, and **Figure 6-4** illustrates the general concept behind the IEIT. **Figure 6-5** illustrates the ponding area filter.

Additional preliminary design, as detailed in **Appendix I**, has been performed on this alternative following its selection as the RMP/PAA. This work has focused primarily on the IEIT measure. Three considerations have been targeted as the most important in design of the IEIT: 1) non-erodibility, 2) particle retention, and 3) stability. Each is discussed below in more detail.

1) Non-erodibility. As discussed in paragraph 2 below, it is unlikely a perfect filter can be designed here since the native soils are highly variable. Instead of relying on this as a standard filter feature, the designer must ensure the backfill will remain in place when the adjacent landward material begins to erode. This will allow the IEIT to serve the intended function of stopping erosion of the soil from continuing backward under the levee. Standards of practice are currently unavailable for designing a material to resist erosion under a certain seepage force. Research has shown, however, that soils containing a wide range of particle sizes are much more erosion-resistant than those of uniform particle size. Therefore, the preliminary backfill material will be composed of a mixture of sand and gravel. Erodibility of the IEIT backfill will be further analyzed later in the design process.

2) Particle retention. The backfill must prevent riverward soil particles from migrating into it. If the backfill were too coarse and therefore contained large enough voids between particles then riverward sand particles could be carried into the voids, initiating erosion that could continue backwards under the levee. Preliminary filter design has been performed and a sand/gravel mixture was found that can prevent the riverward soils from eroding. However, because these native soils are highly variable, one backfill type cannot allow everywhere the free flow of water normally prescribed for a filter. Shallow investigations will be performed later in the design process and will inform the decision to use one backfill type, or two or three backfill types, throughout the trench. If multiple backfills are used, general zones for each would be defined during the design phase. Because the IEIT is not intended to function as a drainage feature, the need to allow the free flow of water exiting the native soils is primarily contingent on erodibility and stability considerations.

3) Stability. Because the IEIT will penetrate the confining layer, high water pressures in the sands and gravels just below this layer would force seepage vertically out of the trench. If the backfill does not have the ability to allow enough water to freely flow through it, it could become unstable, compromising the feature. To avoid this, the berm above the IEIT will have a minimum thickness and a drainage layer that will allow this water to freely flow out the end of the berm. The considerations discussed above for multiple backfill types can help to alleviate this concern if determined necessary.

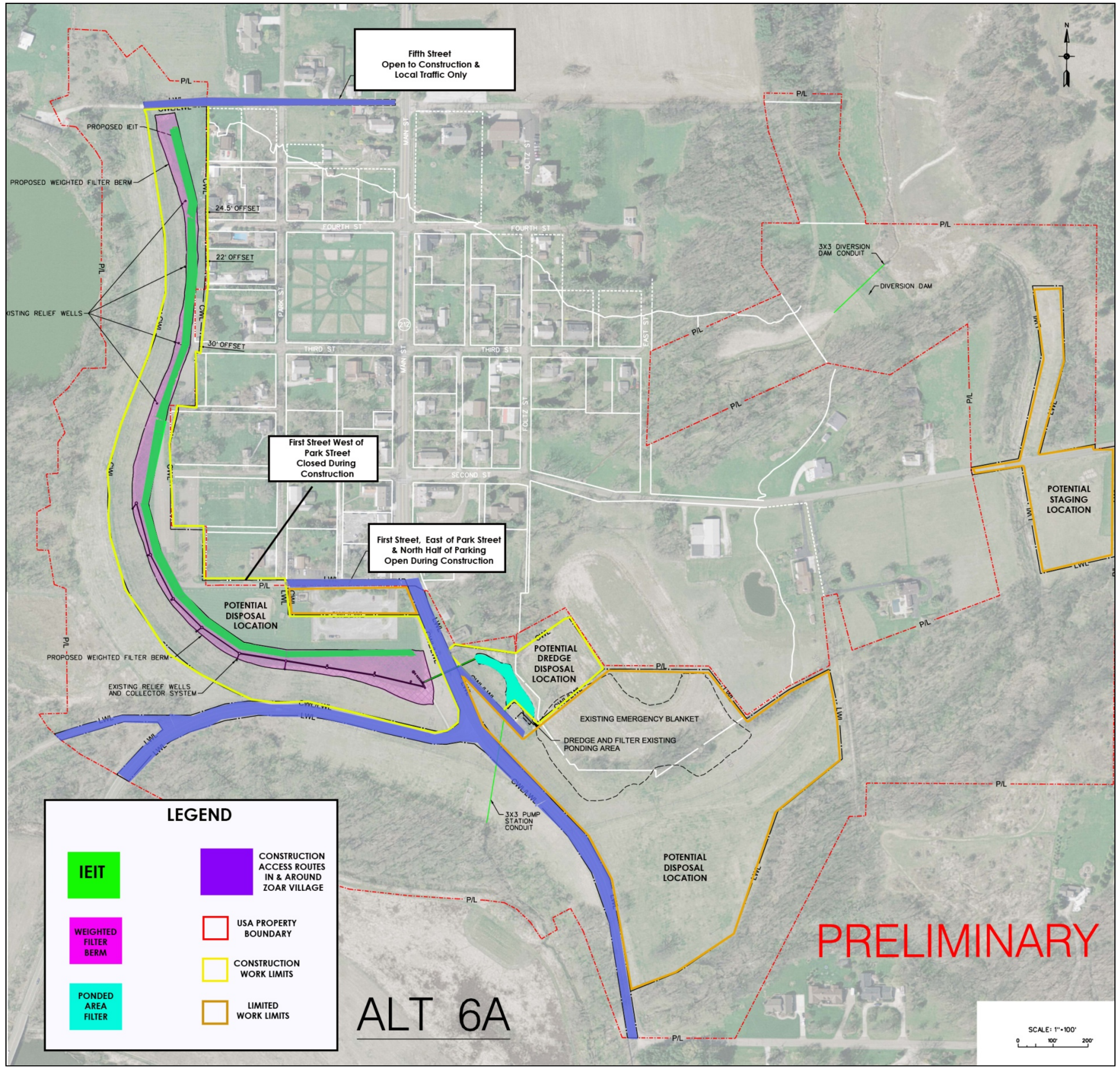

Figure 6-2 Plan view of RMP/PAA showing Construction Work Limits, Limited Work Limits and measures.

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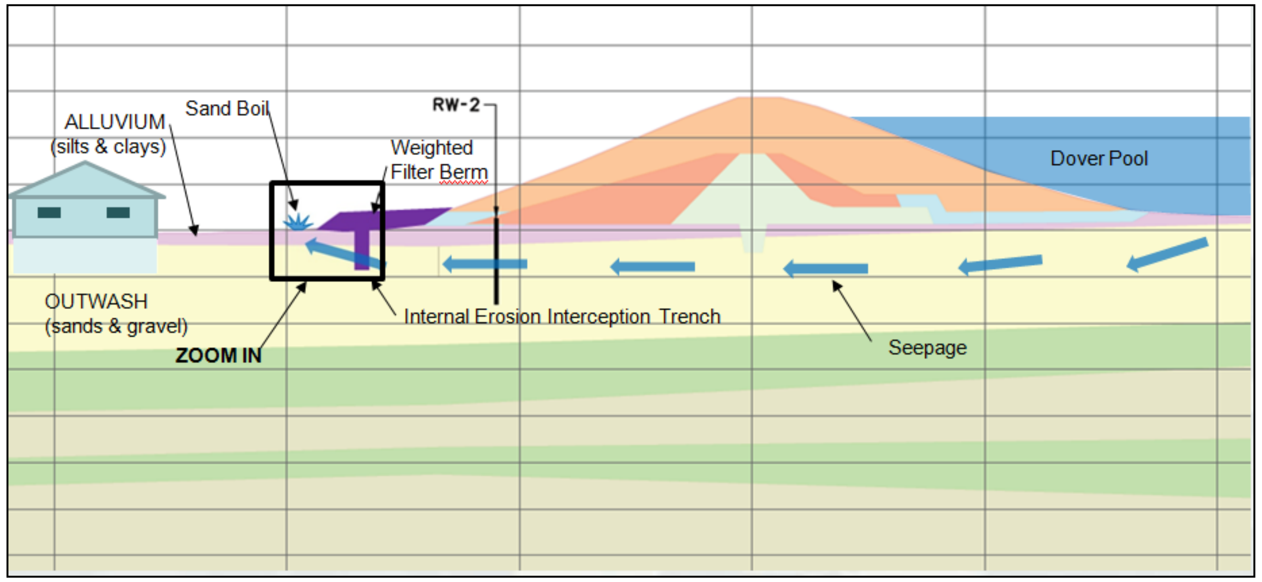

Figure 6-3 Graphic representation of expected risk condition with RMP/PAA at Ball Field Reach.

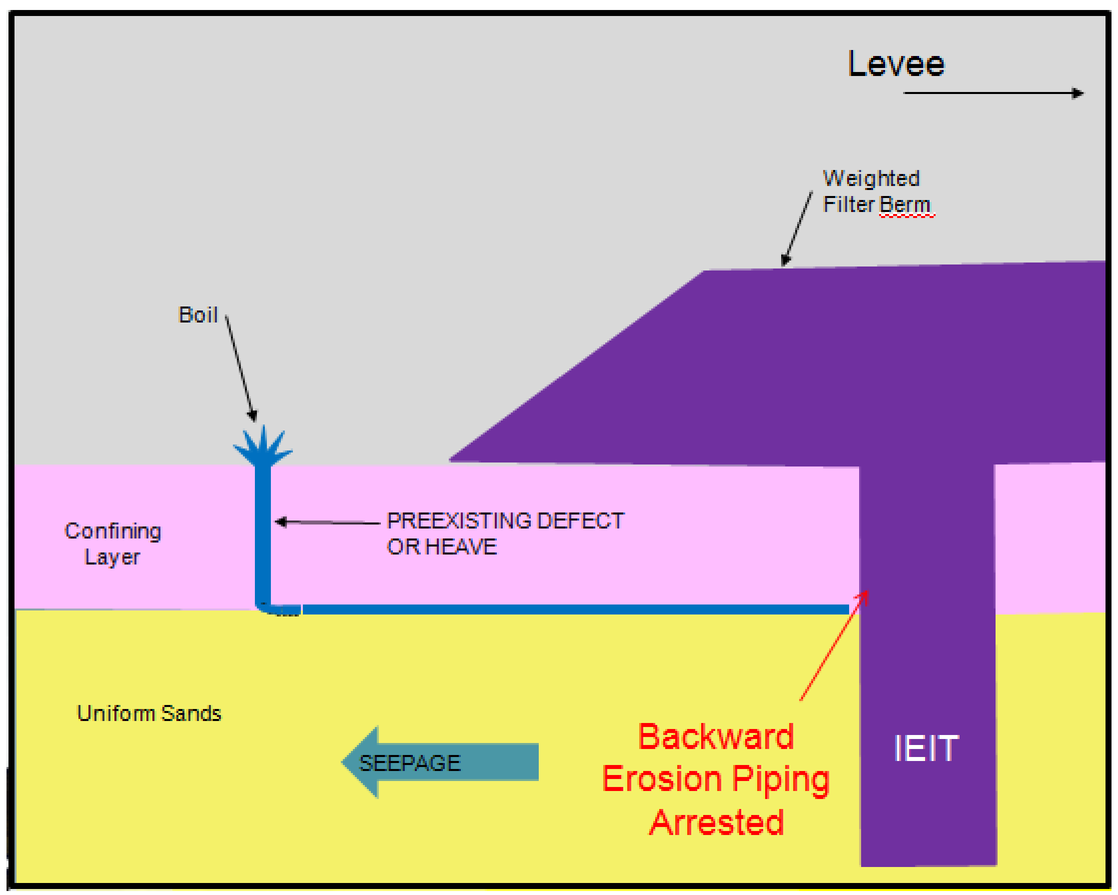

Figure 6-4 Graphic Representation of IEIT arresting backward erosion piping.

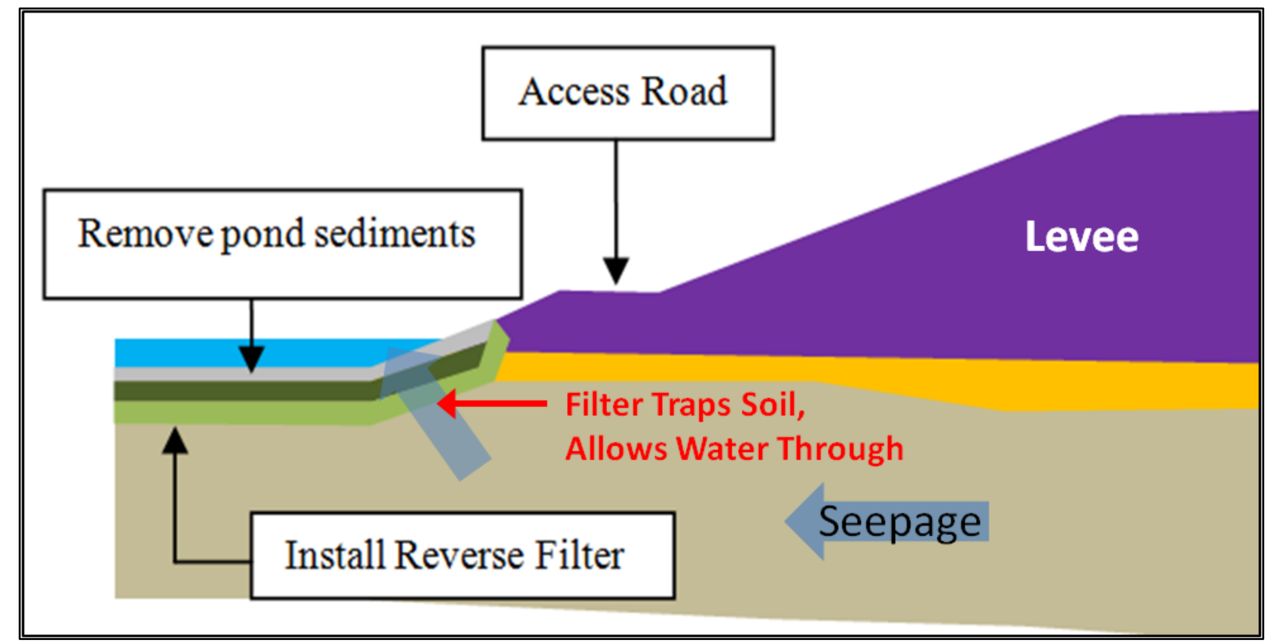

Figure 6-5 Graphic representation of expected performance at Ponding Area.

6.2.2. Cost & Schedule for RMP/PAA

The cost estimate for the project has been developed from detail in the MCACES Second Generation (MII) cost estimating software. The estimate considers all prior and remaining project costs including construction, engineering, design, and contract supervision & administration. Only feasibility costs have been expended through FY16 and are not included in the Total Project Cost Summary (TPCS), since they are not cost-shared.

Cost certification was received on November 13, 2015 from the USACE Cost Mandatory Center of Expertise. The TPCS presents an estimated cost of $11,683,000 at the current price level (November 2015), a Project First Cost of $11,683,000 at the FY16 price level, and a Total Project Cost of $12,436,000 fully funded. See **Appendix C** (M-CACES Estimate for Recommended Plan) and **Appendix G** (Total Project Cost Summary) for additional information and details.

The costs for the selected alternative have increased since the alternative study. These cost increases would have occurred on the other alternatives as well since the features that changed were present for each alternative. The major cost changes can be attributed to the following factors:

- <u>Acquisition Strategy</u>. Alternative study costs assumed an Invitation-for-Bid (IFB) contract for a typical construction company; the baseline assumes a small-business IFB contract, resulting in higher overhead rates and higher costs.
- <u>IEIT Method of Construction & Depth</u>. Alternative study costs assumed construction of the trench via normal construction practices and an average depth of 11 feet; the baseline estimate assumes the IEIT will be constructed to a depth of 20 feet via a trenching machine, resulting in additional material costs as well as higher costs due to the work being performed by a subcontractor.
- <u>Planning, Engineering, & Design (PED)</u>. Alternative study costs were based on a percentage of construction; the baseline is based on a labor analysis assuming two years for design & 13-months for engineering during construction resulting in higher costs.
- <u>Construction Management (S&A)</u>. Alternative study costs were based on a percentage of construction; the baseline is based on a labor analysis assuming 18 months for construction oversight resulting in higher costs.
- <u>Instrumentation</u>. Alternative study costs did not include instrumentation; the baseline assumes installing new piezometers and automating some of the existing piezometers after construction of the IEIT, berm, and reverse filter.

6.2.3. Updated Economic Benefits for RMP/PAA

Table 6-5 below shows the most up-to-date information on the net benefits for the RMP/PAA, incorporating the cost increases discussed in **Section 6.2.2**.

Table 6-5 Current Net Benefits and BCR

Alternative	Average Annual Net Benefits	BCR
6A	-$561,000	.0055

6.3. Real Estate Considerations from RMP/PAA

The RMP/PAA requires the acquisition of approximately 0.18 acre of land across three owners in order to construct, operate, and maintain the project. A qualified appraiser would prepare an appraisal supported by the presentation and analysis of relevant market information in order to determine the fair market value of the real estate to be acquired. This amount would be used as the basis for negotiating the just compensation due the owner. If an agreement cannot be reached with the owner, then condemnation proceedings may be used in order for the court to determine just compensation for the property. The RMP/PAA would also involve potential utility/facility relocation within the work limits. A full Real Estate Plan can be found in **Appendix J**.

6.4. Cost Share Considerations from RMP/PAA

In accordance with an agreement to partner in implementing the projects in the Muskingum River Basin, also known as "The 1934 Agreement", the MWCD originally contributed $12,500,000 of the total cost of $34,590,000 for all dams in the Muskingum Basin (36 percent). The Rivers and Harbors Act of 1938 directed the Secretary of War to reimburse the MWCD $4,500,000, reducing their cost share to $8,000,000, or 23 percent. Therefore, the non-Federal cost share for the Zoar Levee and Diversion Dam, Dam Safety Modification Project is 23 percent of the total project cost, excluding all costs prior to and including report approval of the Dam Safety Modification Report. For further considerations on cost sharing please see **Appendices E, F and H**.

6.5. *Environmental Considerations from RMP/PAA

Action Alternative 6A would have benefits to the affected environment, especially the leveed area, by lowering inundation probabilities and incremental risk to within USACE Tolerable Risk Guidelines. That being said, impacts are anticipated to occur to social, economic, recreational, cultural/historical, and environmental resources from implementation of the RMP/PAA, although it is anticipated that these impacts can be avoided, minimized or mitigated. Therefore, the majority of the potential adverse impacts of the RMP/PAA is either temporary and/or minor in nature and would occur only during construction. These potential impacts will be further reduced by the implementation of best management practices committed to herein.

There is a potential for long-term impacts to archeological resources and to Zoar Village associated with altering the integrity of the historic setting. To resolve any adverse effects that may occur to cultural resources or historic properties, pursuant to Section 106 of the National Historic Preservation Act of 1966, a Programmatic Agreement has been executed in accordance with 36 CFR 800.14(b)(1)(ii) "Use of programmatic agreements". Therefore, while adverse effects may be anticipated with cultural or historical resources from implementation of the RMP/PAA, they will not be significant.

For a more thorough discussion of the anticipated impacts see **Section 5.3** and **Appendix D – Addendum 2**. Cost and schedule contingencies have been developed based on these understandings.

Full compliance with all applicable statutes and Executive Orders is anticipated (see **Table 6-6** below). There has been no opposition to the RMP/PAA expressed by state or local governments, or organized environmental groups, and there are no unresolved issues regarding the implementation of the RMP/PAA.

Table 6-6 Status of compliance with applicable statutes and executive orders

Statute/Executive Order	Full	Partial	N/A
National Environmental Policy Act (considered partial until the FONSI is signed)		X	
Fish and Wildlife Coordination Act (considered partial until completion of coordination)		X	
Endangered Species Act (considered partial until concurrence with the effects determination is received)		X	
Clean Water Act (considered partial until the 401 Certification is obtained)		X	
Wild and Scenic Rivers Act			NA
Clean Air Act	X		
National Historic Preservation Act (considered partial until the programmatic agreement is signed, which would be prior to the issuance of the FONSI)		X	
Comprehensive, Environmental Response, Compensation and Liability Act	X		
Resource Conservation and Recovery Act	X		
Toxic Substances Control Act	X		
Farmland Protection Act	X		
Executive Order 11988 Floodplain Management	X		
Executive Order 11990 Protection of Wetlands	X		
Executive Order 12898 Environmental Justice in Minority Populations and Low-Income Populations	X		

6.6. Considerations to Project Authorization from the RMP/PAA

As discussed in **Section 1.3**, the FCA of 1939 and the Official Plan provide the authority to operate and maintain the 14 dams in the Muskingum River basin, including their upstream appurtenances, like Zoar Levee & Diversion Dam. These dams were constructed to attenuate flooding within the Muskingum Basin. The RMP/PAA would not alter the authorized level of flood risk management in the FCA of 1939 or the Official Plan to any of these 14 dams or their appurtenances, including Dover Dam or Zoar Levee & Diversion Dam. The RMP/PAA would not modify the project in a manner that would require additional authorization. Specifically: (1) no alternations are proposed to Dover Dam; (2) no changes are proposed to Dover Dam's water control plan or manual (which regulate Zoar Levee & Diversion Dam); and (3) no modifications are proposed to Zoar Levee & Diversion Dam that increase or decrease the current level of protection provided. Inadequate operation and maintenance of Zoar Levee & Diversion Dam, or a changed condition, are not the basis for the Final DSMR/EA.

Implementation of the RMP/PAA would address incremental inundation risks to the public from Zoar Levee & Diversion Dam associated with breach prior to overtopping. This action is corrective and addresses a flaw in the design that significantly interferes with the project's full usefulness as intended during the original project development. Specifically, the RMP/PAA would help to make the project function as initially intended by the designer and is justified by dam safety hazards in light of present-day standards and knowledge.

While the RMP/PAA would require a change in the existing Federal real estate interest, it does not include acquisitions in detached areas where Federal real estate interest was not acquired for the original project development.

Therefore, in accordance with ER 1165-2-119, Modifications to Completed Projects, implementation of the RMP/PAA falls within the purview of the original authority granted to the Federal government and within the Chief of Engineers discretionary authority to address dam safety assurance issues.

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7.0 SUMMARY OF IEPR

An Independent External Peer Review (IEPR) for the subject project was conducted in accordance with Section 2034 of the Water Resources Development Act of 2007, EC 1165-2-214, and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review (2004).*

The goal of the USACE Civil Works program is to always provide the most scientifically sound, sustainable water resource solutions for the nation. The USACE review processes are essential to ensuring project safety and quality of products USACE provides to the American people. Battelle Memorial Institute (Battelle), a non-profit science and technology organization with experience in establishing and administering peer review panels for USACE, was engaged to conduct this IEPR.

The Battelle IEPR panel, consisting of experts in the fields of geotechnical engineering, engineering geology, economics/planning, and cultural resources/NEPA impact assessment, reviewed the Final DSMR/EA, as well as supporting documentation. The final IEPR Battelle Report was issued on 23 March 2015.

Overall, 15 comments were identified and documented. Of the 15 comments, three were identified as having high significance, four had medium/high significance, five had medium significance, two had medium/low significance and one had low significance. The comments and responses can be found in Appendix K.

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8.0 SUMMARY AND CONCLUSIONS

The purpose and need for Federal action at Zoar Levee & Diversion Dam is to manage incremental inundation risks outside of USACE Tolerable Risk Guidelines. Incremental risk is defined as risk (likelihood and consequences) associated with the presence of a flood risk management project that can be attributed to its breach prior or subsequent to overtopping, or component malfunction or misoperation. To determine what incremental risks qualify for action and to achieve permission to modify Zoar Levee & Diversion Dam to manage identified incremental risks, a DSMS was completed. In addition, other residual risks were identified that are not considered incremental, but need to be communicated. Finally, the DSMS was utilized to better understand if there is reasonable assurance that Zoar Levee can withstand the base flood event.

8.1. DSMS Summary

An estimate of the existing condition and FWAC/No Action risks was made to better define what, if any, actions were warranted. This analysis indicated that the probability of inundation due to misoperation of the diversion dam or failure of the pumps was 1 in 2,030 chances each year; which is above the USACE TRLL. The FWAC/No Action scenario assumes these probabilities can be lowered below USACE TRLL through the execution of maintenance packages to rehabilitate the two oldest pumps and replace a restriction at the diversion channel. There is uncertainty associated with receiving sufficient funding to accomplish these activities.

While there is uncertainty concerning the nature of the geology which affects the certainty of estimates of breach probabilities, two PFMs (PFM 1A-2 & PFM 1A-4) at Zoar Levee are forecasted to present annual probabilities of breach prior to overtopping that are above the USACE TRLL. Both PFM 1A-2 & PFM 1A-4 were concerned with events associated with backward erosion piping through pervious soils underlying Zoar Levee which could lead to a breach.

Risk estimates indicate that life-loss and economic consequences are relatively low in comparison to other projects in the USACE dam portfolio. Another significant consequence of the resulting inundation would be to the societal value Zoar Village provides as a community, regionally important heritage tourism asset and nationally significant historical site. These consequences combined with the annual probabilities of failure from PFM 1A-2 & PFM 1A-4 create incremental risks that are outside of the USACE Tolerable Risk Guidelines.

To address incremental inundation risks, a wide variety of measures and alternatives were brainstormed, formulated and screened. The final array of action alternatives were designed to:

- Reduce the probability of backward erosion piping starting, by lowering the water pressures placed on the Village-Side of the levee; and/or
- Reduce the probability of any backward erosion piping that started on the Village-Side of the levee progressing underneath the levee and leading to a breach.

The five action alternatives are made up of combined options to treat each PFM specifically, as shown in **Table 8-1**.

Table 8-1 Combinations of options per alternative

ACTION ALT.	BALL FIELD OPTIONS (PFM1A-2)	PONDING AREA OPTIONS (PFM1A-4)
3A	Relief Wells & IEIT	Filter
4A	Partial Weighted Filter Berm & Partial Relief Wells & IEIT	Filter
6A	IEIT	Filter
7A	Partial Length IEIT & Partial Weighted Filter Berm & No Action	Filter
10A	IEIT & Partial Weighted Filter Berm	Filter

Taking no action was also carefully considered and compared against each of the action alternatives. The FWAC/No Action Alternative failed to meet the purpose and need for Federal action and therefore, was not selected.

In summary, the comparison of action alternatives focused on the options to treat PFM 1A-2, as each action alternative included the same option to treat PFM 1A-4. When compared against each other, each action alternative risk management plan was acceptable and found to meet the purpose and need for Federal action, although generally speaking Action Alternative 7A compared poorly against the others. Impacts to the affected environment were also nearly identical. All action alternatives also address all societal concerns expressed during the preparation of the DSMS.

Each action alternative had similar amounts of reduction in risk, but varied in some key components of their overall effectiveness and completeness. For example, Action Alternatives 6A and 7A were considered to have low redundancy, especially with compared to Action Alternative 4A. In addition, Action Alternatives 3A and 4A were considered to have more constructability issues when compared to the others. Long-term operations and maintenance costs associated with relief well maintenance, abandonment and rehabilitation varied. Action Alternative 3A had the highest long-term operation and maintenance costs. Action Alternative 4A had the lowest long-term operation and maintenance costs. The probability of reducing future flood-fighting varied slightly across action alternatives. The biggest differences were that Action Alternatives 6A and 7A did not reduce any annual flood-fighting costs associated with surveillance and limited intervention (standard impacts); whereas the others dropped these costs approximately 30-40 percent.

The single largest distinction among the final array of action alternatives was the cost. None of the action alternatives create positive economic benefits, although as discussed herein, Zoar Levee & Diversion Dam was not authorized to provide traditional economic benefits. With that understanding, when considering the efficiency of the action alternatives, the least-costly alternative was Action Alternative 6A.

Therefore, as Action Alternative 6A meets the purpose and need for Federal action in a manner that supports the expeditious and cost effective reduction of risk, it has been identified as the selected RMP/PAA.

8.2. Residual Risk

Residual risk is risk (likelihood and consequences) that would remain following implementation of the RMP/PAA. Residual risk includes both the remaining incremental risk and non-breach risks. Implementation of future risk reduction actions, including the RMP/PAA in the future, will never fully eliminate the potential for flooding.

8.2.1. Residual Incremental Risk

Following implementation of the RMP/PAA and maintenance changes at the pump station and diversion channel, incremental risk would remain. These estimates assume that the leveed area would not significantly change.

It is estimated that incremental risks associated with pump failure would be lowered from 1 in 5,080 chances every year to 1 in 87,000 chances every year by the execution of maintenance packages to be funded through the operations and maintenance budget request cycle. There is uncertainty that adequate operations and maintenance funding would be available to lower these risks in the near-term, and they may be lowered incrementally as funding is provided.

It is estimated that incremental risk associated with breach of Zoar Levee would be lowered from 1 in 4,550 chances every year to 1 in chances 91,000 every year by the RMP/PAA. When uncertainty in design and construction is considered, the RMP/PAA was estimated to lower annual probability of levee breach to 1 in 23,000 chances every year. These residual risks include the total of PFMs 1A-1, 1A-2, 1A-3, 1A-4, 5A, and 6.

As the RMP/PAA was not designed to manage risk associated with breaching of the diversion dam, no change is estimated to its annual probability of failure (1 in 83,000 chances every year).

8.2.2. Residual Non-Breach Risk

Addressing inundation risk from overtopping was beyond the purpose and need for Federal action, because it does not lead to a breach and therefore, does not qualify as incremental risk. Instead, overtopping is considered Non-Breach Risk, which falls outside of the purpose and need for Federal action.

That being said, it is estimated that overtopping of the levee would continue to present the greatest probability (1 in 6,000 chances every year) of inundation to the leveed area. The consequences of an overtopping event would be similar to a breach or pump failure.

8.3. Levee Accreditation

Finally, at the request of Zoar Village, and on their behalf, USACE has utilized the existing risk condition developed for the DSMS to perform a LSE to determine if Zoar Levee can withstand the base flood event with reasonable assurance. The results indicate this assurance exists, and therefore USACE sent a package to FEMA documenting our positive LSE. Zoar Village is using this positive LSE in support of a request to revise the FIRM to FEMA. FEMA will make an accreditation determination in accordance with the NFIP regulations.

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GLOSSARY

ACHP: Advisory Council on Historic Preservation – An independent agency of the United States government established in 1966 that promotes the preservation, enhancement, and productive use of the nation's historic resources, and advises the President and Congress on national historic preservation policy. ACHP is the only entity with the legal responsibility to encourage Federal agencies to factor historic preservation into Federal project requirements.

APF: Annual Probability of Failure – For dams or levees, the combined estimated annual probability of failure from all failure modes associated with all loading or initiating event types that result in an unintentional release of the reservoir or breaching of a levee.

APE: Area of Potential Effect – That geographic area within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if such properties exist.

ATR: Agency Technical Review – An independent in-depth review designed to ensure the proper application of clearly established criteria, regulations, laws, codes, principles, and professional practices. The ATR team reviews the various work products and assures that all the parts fit together in a coherent whole.

Ball Field Reach: The Ball Field reach of the levee is that portion located west of Route 212 and is called such due to the presence of a Little League Ball Field. The Ball Field reach is built upon a thin intermittent alluvial blanket over top a mix of glacial outwash, alluvium, and lacustrine deposits approximately 130 feet thick in the deepest valley section. This reach extends from station 0+00 to 25+00 on the levee centerline.

BEP: Backward Erosion and Piping –The process of soil erosion that occurs when individual grains are removed by water flowing through the soil mass, creating channels, or pipes, that begin at the water's exit point and continue to erode back towards the water's entry point. When this process continues unchecked through or under a dam or levee, the pipes can enlarge, allowing increased water flow and soil erosion, and eventually lead to failure.

BLRA: Baseline Risk Assessment – An engineering evaluation of the dam/levee structural, electrical, mechanical, hydraulic and geotechnical components and operational processes dedicated to identifying various project failure modes and the risks associated with each mode, component or system that could initiate or lead to project failure.

<u>Collector</u> – Buried pipe system that conveys relief well outflows to the ponding area.

<u>CWA</u>: Clean Water Act - The primary Federal law governing water pollution. Passed in 1972, the objective of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA), is to restore and maintain the chemical, physical, and biological integrity of the nation's waters by preventing point and nonpoint pollution sources, providing assistance to publicly owned treatment works for the improvement of wastewater treatment, and maintaining the integrity of wetlands.

<u>Detailed Design Report (DDR)</u> – The DDR is a design document that provides the technical basis for the Plans and Specifications (P&S). It serves mainly as a summary of the design to be used by the Project Delivery Team (PDT) during development of the P&S. The DDR is used for reviewing the design and the P&S and is available for future reference. The DDR is primarily an engineering document developed by the Lead Engineer (LE) in cooperation with the PDT.

<u>DSPC</u>: Dam Safety Production Center, U.S. Army Corps of Engineers Organization Responsible for Dam Safety Modification Study and Reporting.

<u>DSAC</u>: Dam Safety Action Classification system developed by U.S. Army Corps of Engineers to provide consistent and systematic guidelines for appropriate actions to address dam safety issues and deficiencies at U.S. Army Corps of Engineer's projects. Projects are assigned a DSAC informed by the probability of failure and incremental risk. The DSAC ratings range from DSAC 5, Normal, to DSAC 1 Very High Urgency. The DSMS was initiated as a result of the DSAC 1 designation. In accordance with ER 1110-2-1156, DSAC 1 projects move directly into a DSMS, skipping an Issue Evaluation Study.

<u>DSMR</u>: Dam Safety Modification Report is the US Army Corps of Engineers report documenting the results of a Dam Safety Modification Study.

<u>DSMS</u>: Dam Safety Modification Study is a study to obtain approval for a U.S. Army Corps of Engineers project to address risk associated with dam safety issues that would result in unacceptable life-safety, economic and environmental risk, if the project were to fail.

<u>EA</u>: Environmental Assessment documents the potential environmental effects of the various alternative risk management plans to determine whether a Finding of No Significant impact (FONSI) or an Environmental Impact Statement (EIS) is required.

<u>Effects Risk Register</u> – Documented register developed by Section 106 Consulting Parties to identify potential effects that could result from implementation of any one of the final array of alternatives. In addition, this register developed potential management options to avoid, minimize, or otherwise mitigate for the potential effects

EOE: Expert Opinion Elicitation – In engineering circles, expert elicitation is the synthesis of opinions of authorities on a subject where there is uncertainty due to insufficient data or when such data is unattainable because of physical constraints or lack of resources. Expert elicitation is essentially an engineering consensus method. It is often used in the study of rare events. Expert elicitation allows for parameterization or an "educated guess" for the respective topic under study. Expert elicitation generally quantifies risks and uncertainty.

EQ: Environmental Quality – One of the four social/economic/environmental accounts used by USACE to compile benefit and cost outputs (including non-monetary impacts) of project alternatives for comparison and selection purposes and specifically addresses information developed and documented to disclose environmental and cultural resources impacts through NEPA and other environmental and cultural resources policy and regulatory requirements.

FEMA: Federal Emergency Management Agency – An agency of the United States Department of Homeland Security initially created in 1978 and implemented by Executive Orders. The agency's primary purpose is to coordinate the response to a disaster that has occurred in the United States and that overwhelms the resources of local and state authorities. FEMA provides funds for training of response personnel throughout the United States and its territories through the agency's preparedness programs. FEMA administers the Hazard Mitigation Grant Program and is responsible for the accreditation or de-accrediting of levees and floodwalls based upon the engineering certification of a Professional Engineer or Federal agency. FEMA manages the National Flood Insurance Program and oversees the floodplain management and mapping components of that Program.

Historic Property - Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior.

Huntington District – Huntington District is an installation within U.S. Army Corps of Engineers (USACE), and Major Command within the Department of the Army that encompasses 45,000 square miles in parts of five states including portions of Ohio. Huntington District has primary responsibility to operate and maintain Zoar Levee & Diversion Dam.

HTRW: Hazardous, Toxic and Radioactive Wastes - Except for dredged material and sediments beneath navigable waters proposed for dredging, HTRW includes any material listed as a "hazardous substance" under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Hazardous substances regulated under CERCLA include "hazardous wastes" under Sec. 3001 of the Resource Conservation and Recovery Act, "hazardous substances" identified under Section 311 of the Clean Air Act, "toxic pollutants" designated under Section 307 of the Clean Water Act, "hazardous air pollutants" designated under Section 112 of the Clean Air Act, and "imminently hazardous chemical substances or mixtures" on which EPA has taken action under Section 7 of the Toxic Substance Control Act; these do not include petroleum or natural gas.

IEIT: Internal Erosion Interception Trench – Structural measure that involves a shallow slot excavation backfilled with a less erodible material that penetrates the confining layer and extends into the glacial outwash foundation with the principle that the backward erosion piping channels would be intercepted as they progress backwards toward the river. Shallow penetration and material for backfill would not provide significant pressure relief.

IES: Issue Evaluation Study – Issue Evaluation Studies for dams classified in DSAC classes 2, 3 and 4 are studies to better determine the nature of the Dam Safety issue and the degree of urgency for action within the context of the full USACE inventory of dams.

Incremental Risk – Incremental risk for levee systems arises when levee system flood defenses do not perform as planned. The flood risk for a levee-protected area attributed to the levee system in its existing condition is determined by subtracting the without breach flood risk from the flood risk with the levee performing in its existing condition (all failure modes and consequences assessed). As a matter of policy this difference is called the incremental flood risk due to the presence of the levee system. Note that for a floodplain that is not protected by a levee, there is no infrastructure present to impede the flood hazard from inundating the floodplain, so there is no incremental risk.

IRRM: Interim Risk Reduction Measure – Dam Safety risk reduction measures that are to be formulated and undertaken for dams or levees that are not considered to be tolerably safe and are intended as interim until more permanent remediation measures are implemented. Increased monitoring and levee loading restrictions are examples of interim measures that can be taken at a project.

LRD: Great Lakes & Ohio Rivers Division, a Major Subordinate Command under U.S. Army Corps of Engineers based in Cincinnati, Ohio.

LSE: Levee System Evaluation - A technical finding that, for the floodplain in question, there is a reasonable assurance that the levee system will exclude the 1% annual chance exceedance flood (or base flood) from the leveed area based on the condition of the system at the time the determination is made.

MWCD: Muskingum Watershed Conservancy District is a political subdivision of the State of Ohio organized to develop and implement a plan to reduce the effects of flooding and conserve water for beneficial public uses under Ohio Revised Chapter 6101 (commonly called the Conservancy Act). The MWCD is a partner with the U.S. Army Corps of Engineers (USACE) in the operation of the system of dams and reservoirs in the Muskingum Watershed, including Dover Dam, of which Zoar Levee & Diversion Dam is an appurtenance.

NED: National Economic Development – One of the four social/economic/environmental accounts used by USACE to identify and compile benefit and cost outputs of project alternatives for comparison and selection purposes and specifically addresses monetized costs and benefits of alternatives that contribute to the national output of goods and services from that alternative or plan.

NEPA: National Environmental Policy Act – Basic national charter for protection of the environment to ensure that federal agencies to among other things, identify and assess the reasonable alternatives to proposed actions that would avoid or minimize adverse effects of proposed actions upon the quality of the human environment.

NFIP: National Flood Insurance Program – A program administered by the Federal Emergency Management Agency that enables property owners in participating communities to purchase insurance protection from participating private companies against losses to structures and building contents from flooding. This insurance is designed to provide an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods. The Village of Zoar is participating in the NFIP.

NHPA: National Historic Preservation Act – An act to establish a program for the preservation of additional historic properties throughout the nation.

NHL: National Historic Landmarks (NHL) are nationally significant historic places designed by the Secretary of the Interior because they possess exceptional value or quality in illustrating or interpreting the heritage of the United State.

NRHP: The National Register of Historic Places (NRHP) is the official list of the Nation's historic places worthy of preservation.

NTHP: National Trust for Historic Preservation – A privately funded, nonprofit organization based in Washington, D.C., that works in the field of historic preservation in the United States. The member-supported organization was founded in 1949 by Congressional Charter to support the preservation of America's diverse historic buildings, neighborhoods, and heritage through its programs, resources, and advocacy.

<u>OECC</u>: Ohio & Erie Canalway Coalition – Established in 1989, the Ohio & Erie Canalway Coalition is a private, non-profit organization working on the development of the Ohio & Erie National Heritage Canalway. The Coalition provides educational programs, events and publications about the Heritage Canalway while developing strong working relationships with partners to preserve and interpret the natural, historical and recreational resources throughout the corridor.

<u>OHC</u>: Ohio History Connection [Formally Ohio Historical Society (OHS)] – Founded in 1885, the non-profit Ohio History Connection (www.ohiohistory.org) provides a wide array of statewide services and programs related to collecting, preserving and interpreting Ohio's history, archaeology and natural history through its 58 sites and museums across Ohio.

<u>OHPO</u>: Ohio Historic Preservation Office – The official historic preservation agency of the State of Ohio. It has developed since 1967 when the Ohio History Connection was designated to manage responsibilities delegated to the state by Congress in the National Historic Preservation Act of 1966. Among its many duties and programs are preparation and distribution of a state historic preservation plan, identification of historic places and archaeological sites, nominating eligible properties to the National Register of Historic Places, reviewing rehabilitation work to income-producing National Register properties for federal investment tax credits, consulting on significance and proposed federally-assisted projects for effects on historic, architectural, and archaeological resources, qualifying communities for the Certified Local Government program and administering matching grants to them, consulting on the conservation of buildings and sites, and offering educational programs and publications.

<u>OSE</u>: Other Social Effects – One of the four social/economic/environmental accounts used by USACE to compile benefits and costs of project alternatives for comparison and selection purposes and specifically addresses social, cultural and economic benefits and costs (monetized and non-monetized) of alternative plans not addressed in the NED, EQ or RED accounts (also defined herein).

<u>PAA</u>: Preferred Action Alternative – The PAA is the action alternative identified or preferred by USACE that meets the purpose and need for Federal action.

<u>PFM</u>: Potential Failure Mode – The chain of events leading to dam/levee failure or a portion thereof that could lead to dam failure. The dam does not have to completely fail in the sense of a complete release of the impounded water.

<u>PFMA</u>: Potential Failure Mode Analysis – A PFMA is an examination of "potential" failure modes for an existing dam or levee by a team of persons who are qualified either by experience and/or education to evaluate dams and levees. It is based on a review of existing data and information, including but not limited to: first hand input from field and operational personnel, site inspection, completed engineering analyses, discussion of dam/levee characteristics, failure causes and an understanding of the consequences of failure. A PFMA is intended to provide enhanced understanding and insight on the risk exposure associated with the dam or levee.

Piezometer – An instrument used to measure static underground water pressure by measuring the height to which a column of the water rises against gravity. There are a number of these instruments located along the interior toe of Zoar Levee to measure the presence and pressure of water within the levee foundation.

Plans and Specifications (P&S): – The P&S is one product completed during the Pre-construction, Engineering and Design (PED) Phase and the key output of the Design Documentation Report (DDR) process. The P&S are a portion of the legal construction documents that display in graphic and text form the construction features, materials, and techniques that form the basis for the USACE estimated project cost, are the basis for Contractor(s) bids on the project, guide the selected construction Contractor(s) to accomplish the approved project and the legal documents by which the USACE resident engineer inspects the sufficiency and quality of the completed work and approves payment of Contractor's invoices for work completed.

Ponding Area – That component of an interior drainage system for a levee or floodwall located upstream from a pumping station that has a permanent project flowage easement and stores excess interior stormwater runoff during rainfall events thereby allowing a reduction in the overall pumping capacity required.

P&G: Principle & Guidelines – The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies codified and implemented by Executive Order 11747 in 1983 and defines procedures for consistent water resources planning though systematic formulation and evaluation of water resources development alternative plans.

RED: Regional Economic Development – One of the four social/economic/environmental accounts used by USACE to compile benefits and costs of project alternatives for comparison and selection purposes and specifically addresses regional changes in distribution of economic activities that could result as outputs of alternative plans. Two measures of the effects of the plan on regional economies are used in the account: regional income and regional employment.

Relief Wells: A series of excavated wells located at or near the interior levee toe that provide a pressure outlet (through a collector system that drains to the ponding area) to relieve groundwater pressures caused by underseepage.

Resident Engineer (RE): The USACE RE is the primary Huntington District point of contact during the Construction Phase. The RE is responsible for enforcement of the contract documents and applicable laws, regulations and policies regarding Federal construction.

Risk Management Plan / Preferred Action Alternative (RMP/PAA): Alternative proposed to meet the purpose and need of the Dam Safety Modification Study (DSMS).

Rock Knoll Reach: The Rock Knoll reach is that portion of the levee located east of Route 212 and is generally characterized by colluvial/residual deposits of variable thickness, situated on a localized bedrock high point; this area was “high ground” prior to the raising of the levee in 1951. This Rock Knoll consists of jointed and fractured sandstone and limestone, interbedded with shale. This section extends from station 25+00 to 39+12 along the levee centerline.

TCHS & EMA: Tuscarawas County Homeland Security and Emergency Management Agency – Agency designated with the responsibilities of county-wide and community-level emergency preparedness, response, recovery and mitigation of natural and man-made disasters including flooding and potential infrastructure failures. TCHS & EMA is the agency that would be responsible for notifying Village leadership of the necessity of evacuation based upon advice from the Huntington District Dam Safety Officer.

T&E: Threatened & Endangered Species – A Federally-protected (Endangered Species Act (1973) list of aquatic and terrestrial species including mammals, reptiles, birds, and plants and their habitats.

Toe Drain: Trench (generally trapezoidal) with a designed penetration depth to meet pressure relief requirements with a perforated pipe that conveys outflows to the ponding area.

TRG: Tolerable Risk Guidelines – Tolerable risk guidelines are a set of principles used in risk management to guide the process of examining and judging the significance of estimated risks obtained from risk assessment where “tolerable risks” are defined as: 1) risks that society is willing to live with so as to secure certain benefits, 2) risks that society does not regard as negligible or something that it might ignore, 3) risks that society is confident that are being properly managed by the owner, and 4) risks that the owner keeps under review and reduces still further if and as practicable. Four risk measures are evaluated under the USACE tolerable risk guidelines including annual probability of failure; life safety risk; economic risk; and environmental and other non-monetary risk.

TRLL: Tolerable Risk Limit Line – Defines the limit of unacceptable risk due to annual probability of failure, which corresponds to a 1 in 10,000 chance. When risks plot *above* the TRLL, they are outside of the Tolerable Risk Guidelines. When risks plot *below* the TRLL, they are within the Tolerable Risk Guidelines.

USFWCA: U.S. Fish & Wildlife Coordination Act – The Fish and Wildlife Coordination Act (FWCA) was enacted March 10, 1934 to protect fish and wildlife when federal actions result in the control or modification of a natural stream or body of water. The Act provides the basic authority for the involvement of the US Fish and Wildlife Service (Service) in evaluating impacts to fish and wildlife from proposed water resource development projects.

USACE: U.S. Army Corps of Engineers, a Major Command of the Department of Army

WCM: Water Control Manual – An official USACE legal document that relates primarily to the functional regulation of an individual water resources project that can be either single-purpose or multi-purpose in nature. This manual includes the project water control plan and features operations for flooding as well as drought conditions. The manual includes background information concerning physical features of the project and is hydrologic watershed, but does not prescribe rules or methods for physical maintenance or care of facilities. The effects of non-USACE projects are considered in appropriate detail, including an indication of provisions for interagency coordination.

Weighted Filter Berm: The berm is an engineered embankment of graded soil materials extending the length of and covering the proposed internal erosion interception trench to reduce the likelihood of alluvial breaches occurring between the trench and the toe of the levee. The embankment would transport any captured underseepage to a collection system.

Zoar Historic District – The Zoar Historic District includes those portions of the Zoar Village, the Zoar Village Historic Site and the surrounding areas that have been listed, determined eligible, or considered eligible for listing in the National Register of Historic Places.

Zoar Village: Zoar Village is defined as the municipal jurisdiction in Lawrence Township, Tuscarawas County, Ohio.

Zoar Village Historic Site: Zoar Village Historic Site is defined as that portion of Zoar Village which is owned by the State of Ohio, the Ohio History Connection, Zoar Village and the Zoar Community Association which is operated as an interpretative historic site open to the public.

ZCA: Zoar Community Association – A non-profit 501(c)(3) organization, founded in 1967, composed of Zoar residents and interested citizens committed to the future preservation and prosperity of the Village. The ZCA mission is to preserve, interpret and celebrate the culture and heritage of the Society of Separatists and Historic Zoar Village through education, activities, and events that promote both the legacy of the Society and the present Zoar Community.

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