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ENGINEERING AND CONSTRUCTION BULLETIN

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SUBJECT: Clarification of Policies and Guidance Associated with the Welding of Hydraulic Steel Structures (HSS)

CATEGORY: Policy and Guidance

1. References

- a. Engineer Manual (EM) 1110-2-2107, Design of Hydraulic Steel Structures, 1 AUG 2022.
- b. EM 1110-2-6054, Inspection, Evaluation and Repair of Hydraulic Steel Structures, 1 DEC 2001.
- c. Engineer Regulation (ER) 1110-1-8152, Professional Registration and Signature on Design Documents, 24 JAN 2012.
- d. ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 AUG 1999.
- e. ER 1110-2-1156, Safety of Dams - Policy and Procedures, 31 MAR 2014.
- f. ER 1110-2-8157, Responsibility for Hydraulic Steel Structures, 15 JUN 2009.
- g. ER 1165-2-217, Civil Works Review Policy, Water Resource Policies and Authorities, 1 MAY 2021.

2. Purpose

a. This Engineering and Construction Bulletin (ECB) amends and clarifies the intended use of EM 1110-2-2107, and summarizes key policies, roles, guidance, and procedures with respect to welding quality associated with ER 1110-2-8157, EM 1110-2-2107, and EM 1110-2-6054. The purpose of this ECB is to ensure qualified personnel within Operations and Engineering are properly designing, executing, and inspecting welding fabrication, rehabilitation, and repairs to hydraulic steel structures (HSS) in a coordinated, collaborative, and consistent manner.

b. The guidance provided in this ECB addresses the roles and responsibilities of the designated Engineer or Engineer of Record (EOR) such that structures are fabricated, rehabilitated, or repaired per ER 1110-2-8157 requirements. While additional engineering disciplines, including mechanical and electrical, are typically included in HSS design, this ECB does not address those requirements. The Engineer must ensure that proper coordination of all required disciplines from Engineering, Operations, and Construction are included in the design of new HSS as well as in the rehabilitation or repair of existing structures.

3. **Applicability.** This ECB applies to U.S. Army Corps of Engineers (USACE) Engineering and Construction (E&C) personnel working within the Civil Works Program.

4. Background

a. The intent of ER 1110-2-8157 is to ensure a qualified engineer is reviewing and approving the design, rehabilitation, and repair of all HSS. As per ER 1165-2-217 and ER 1110-2-8157, the District's Chief of Engineering has ultimate signature authority on all HSS documentation, thereby approving final fabrication, rehabilitation, and repair at the direction of the EOR – ultimately certifying on behalf of USACE that each HSS has been properly documented per ER 1110-2-8157 requirements.

b. Recent modifications and repairs to HSS have been conducted without coordination with the EOR. Work was completed by uncertified welders without the use of a welding procedure specification (WPS) and without appropriate quality control (QC) and quality assurance (QA) being performed. Per ER 1110-2-8157, all welding to HSS (new or existing) must be performed by certified welders with an applicable WPS per code of fabrication (i.e., AWS D1.1 or AWS D1.5) and must have proper QC and QA testing.

5. Policy

a. The Chief of Engineering designates a qualified engineer to be the Engineer or EOR for all HSS. The Engineer or EOR role requirements are detailed in ER 1110-2-8157.

b. To meet ER 1110-2-8157 requirements, all welding on new or existing HSS must be conducted under the review and approval of the EOR. Welding must be performed by welders who are certified to the code of fabrication (AWS D1.1 or AWS D1.5), utilizing applicable WPS and required QC and QA.

c. In accordance with EM 1110-2-2107, the Engineer must evaluate all new structures, or existing structures requiring rehabilitation, according to the load case requirements specified in the EM. The intent of evaluating these structures according to the required load cases is to ensure all are designed or rehabilitated for the required load cases previously developed for reliable and safe operation of the structure. When HSS require repair the engineer should review original design loads and load cases and compare to existing guidance. The EOR, in coordination with Operations, should determine the appropriate extent of repair or if rehabilitation or replacement of the structure is required. Repairing a structure restores its function until rehabilitation or replacement can occur.

d. The fabrication of new HSS, as well as the rehabilitation and repair of existing structures, must be completed with the appropriate QC and QA necessary to meet ER 1110-2-8157 requirements. Mandatory inspection requirements, including additional nondestructive testing (NDT), such as Magnetic Particle (MT), Dye Penetrant (PT), Ultrasonic (UT) and Radiographic testing (RT), as well as visual inspection of welds must be completed. Documentation of the NDT for QC and verification testing for QA is a mandatory requirement of ER 1110-2-8157.

e. Documentation detailing mandatory NDT is the responsibility of the Engineer and must be recorded and stored in the HSS database. The HSS database managed by Walla Walla District should be used to store all information associated with each structure.

6. Guidance

a. The guidance and attachments of this ECB summarize qualification requirements and outline responsibilities and processes associated with the fabrication of new HSS and the rehabilitation or repair of existing HSS. The attachments include flow charts that identify individual roles and responsibilities associated with ensuring new and existing hydraulic steel structures are properly designed, fabricated, rehabilitated, or repaired to meet ER 1110-2-8157 requirements.

b. It is not the intent of EM 1110-2-2107 that existing HSS, currently in service, be repaired to meet the standards contained in EM 1110-2-2107 and UFGS 05 59 20. However, these documents must be applied to new HSS to ensure the requirements of ER 1110-2-8157 *Responsibility for Hydraulic Steel Structures* have been met and that all new HSS are delivered with documentation confirming they are certified for use and do not require an additional initial HSS inspection. To clarify technical requirements for repair of HSS, a new guide specification will be authored that addresses the repair work per ER 1110-2-8157 requirements. To improve the application of guidance, EM 1110-2-2107 is amended as follows:

(1) Amend Section 1 by striking the words “and repair” from the purpose of the manual. See amended excerpt below:

“Purpose. This manual prescribes guidance for the design of Hydraulic Steel Structures (HSS) by load and resistance factor design (LRFD). This includes design of new structures, replacement, and rehabilitation.”

(2) Amend Section 1.1 by striking the words “and repair” from the purpose of the manual. See amended excerpt below:

“Purpose. This manual prescribes guidance for the design of Hydraulic Steel Structures (HSS) by load and resistance factor design (LRFD). This includes design of new structures, replacement, and rehabilitation.”

c. ER 1110-2-8157 requires the District’s Chief of Engineering to designate a qualified engineer as the Engineer or EOR for all HSS. Since the Chief of Engineering could be a Professional Engineer from a non-structural engineering discipline (e.g., electrical or hydraulic) who is not familiar with structural steel design and fabrication, this formal designation of a qualified engineer ensures all HSS requirements are met per ER 1110-2-8157. The qualified engineer must be:

- (1) a structural engineer with at least 5 years of experience in the design and inspection of HSS,
- (2) have completed course work in structural steel design, fatigue, and fracture, and
- (3) have experience with structural steel fabrication.

Additionally, the Engineer is responsible for informing the Chief of Engineering if ER requirements are not met. In all instances (new HSS fabrication, rehabilitation, or repair), the Engineer must ensure the HSS meets ER 1110-2-8157 requirements.

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d. The EOR, Operations staff, and Construction staff must coordinate in advance of and throughout an HSS project to make certain the requirements of ER 1110-2-8157 are met. The EOR must solicit input from Operations staff to ensure operational needs, lessons learned and experience in operating and utilizing the HSS are incorporated into the project. Operations must provide adequate funding for the EOR, Construction, and Operations staff to ensure proper QC and QA are conducted throughout all phases of fabrication, rehabilitation, or repair.

e. QA of welding (Visual inspection and NDT) is an independent activity that must occur after all QC is complete. QA will typically require a third-party contractor or utilization of the Welding and Metallurgy TCX QA staff. The EOR should be onsite for all QA activities to verify proper QA is being conducted in accordance with ER 1110-2-8157 requirements.

f. Detailed guidance and recommendations for new HSS fabrication, rehabilitation, and repair are provided as attachments to this ECB. These are intended to be general “roadmaps” for proper execution and should be reviewed prior to and throughout all HSS projects.

7. **Updates.** New requirements will be included in updates to EM 1110-2-2107, ER 1110-2-8157, and EM 1110-2-6054 to reinforce these requirements upon expiration of this ECB.

8. **Point of Contact.** The HQUSACE E&C Point of Contact for this ECB is Mr. Chris Westbrook, CECW-EC, (202) 761-7584.

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Encl.

Attachment A – Fabrication of New Hydraulic Steel Structures

Attachment B – Rehabilitation of Existing Hydraulic Steel Structures

Attachment C – Repair of Existing Hydraulic Steel Structures

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ATTACHMENT A – FABRICATION OF NEW HYDRAULIC STEEL STRUCTURES

ABBREVIATIONS

AASHTO	American Associate of State Highway and Transportation Officials
AISC	American Institute of Steel Construction
AMPP	The Association for Materials Protection and Performance
ANSI	American National Standards Institute
ASNT	American Society of Nondestructive Testing
ATR	Agency Technical Review
AWS	American Welding Society
CWI	Certified Welding Inspector
CX	Center of Expertise
DQC	District Quality Control
DSOG	Dam Safety Oversight Group
EDC	Engineering During Construction
EM	Engineering Manual
EOR	Engineer of Record
ER	Engineering Regulation
FCM	Fracture Critical Member
FCP	Fracture Control Plan
HDC	Hydroelectric Design Center
HSS	Hydraulic Steel Structure
HYD, HYDA	Hydraulic Fabricator, Hydraulic Fabricator Advanced
INDC	Inland Navigation Design Center
LSOG	Levee Safety Oversight Group
MSC	Major Subordinate Command
MT	Magnetic Particle Testing
NDT	Nondestructive Testing
PDT	Project Delivery Team
PQR	Procedure Qualification Record
PT	Penetrant Testing (Dye Penetrant Testing)
QA	Quality Assurance
QC	Quality Control
RCSC	Research Counsel on Structural Connections
RFI	Request for Information
RMC	Risk Management Center
RMO	Review Management Organization
RT	Radiographic Testing
TCX	Technical Center of Expertise
USACE	U.S. Army Corps of Engineers
UT	Ultrasonic Testing
VE	Value Engineering
VT	Visual Testing (Visual Inspection)
WPS	Welding Procedure Specification

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The general steps outlined below are necessary for designing and fabricating new HSS.

1. Designate the Engineer or Engineer of Record (EOR) per ER 1110-2-8157 requirements.

The Engineer, meeting the qualifications as defined by ER 1110-2-8157, must perform, or oversee the performance of the design, fabrication, and installation of hydraulic steel structures (HSS).

2. Design the structure per EM 1110-2-2107 requirements and load cases.
 - a. All newly fabricated HSS must be designed according to the latest edition of EM 1110-2-2107. Existing designs used for new work must be modified to meet all provisions of EM 1110-2-2107.
 - b. Engineering responsibilities for the design of HSS are prescribed by ER 1110-2-8157. HSS must be designed according to EM 1110-2-2107, AISC *Specification for Structural Steel Buildings* and ANSI/AISC 360-16, except as specified in EM 1110-2-2107. Welding requirements must follow AASHTO/AWS D1.5M/D1.5 and utilize UFGS 05 59 20.
 - c. Design review requirements must be followed in accordance with ER 1110-2-1150, ER 1110-2-1156, and ER 1165-2-217, ensuring DQC and ATRs are completed for all structures. Ensure all review plans are coordinated through the appropriate RMO. The RMO for a structure must be determined according to ER 1165-2-217, Table 2.1. The RMO may be the RMC, INDC, or the MSC, as appropriate, based on the type of work.
 - d. In accordance with USACE ECB 2023-4 *Engaging Centers of Expertise in Project Delivery Teams and New Website-- Category: Directive and Policy* the Engineer must engage and utilize Centers of Expertise (CXs) as required per ER 1110-1-8158.

Typical CXs involved in HSS include (but are not limited to): Corrosion Control and Cathodic Protection TCX, Welding and Metallurgy TCX, and the Paint Technology Center CX.

- e. Coordination with Operations Division(s), project site personnel, and/or end users is required during all design phases.
- f. Justification for deviations and waivers from mandatory design standards in EM 1110-2-2107 must include a risk assessment. All deviations and waivers must be clearly identified in the decision documents and design reports and must be deliberately called out within the review plan as a specific charge for the review.

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- g. All proposed deviations and waivers from the mandatory design standards provided in EM 1110-2-2107, including rationale, must be documented in a memorandum approved by the respective District and Division Dam or Levee Safety Officer and concurred by the Dam or Levee Safety Oversight Group (DSOG or LSOG), whichever is appropriate. The DSOG or LSOG will ensure the appropriate USACE Community of Practice leader(s), or their designated representatives, are included in the concurrence process.
- h. Per ER 1110-2-8157, the fabrication of new HSS with potential loss of life, to include USACE personnel, contractors, and/or the downstream population, must also utilize EM 1110-2-2107 and AWS D1.5 (as amended by UFGS 05 59 20). For HSS without life safety implications, the EOR may utilize a risk-informed design approach to determine the appropriate specification requirements with concurrence from the EOR and the District's Chief of Engineering.
- i. The majority of HSS include Fracture Critical Members (FCMs) that must be fabricated to ER 1110-2-8157 requirements and include a Fracture Control Plan (FCP). An FCP reduces the risk of fracture in a structure by ensuring the material, welds, and completed fabrication include the necessary QC and QA requirements. AWS D1.5, Clause 12, is the only fabrication code which contains an FCP. Utilizing AWS D1.5 removes the burden of authoring an FCP from the EOR.
 - i. Utilizing a code other than AWS D1.5 for fabrication of a new HSS that has FCMs would require a new FCP authored by the EOR as part of the specific contract. USACE would then enforce those requirements on the fabricator.
 - ii. A fabricator who has not previously performed work to AWS D1.5, Clause 12, and is thereby unfamiliar with the recording requirements of an existing QC program, would be placed at a considerable disadvantage that could create a situation where USACE would have difficulty performing QA. To minimize the risk of selecting a fabricator who cannot perform the necessary QC as required by an FCP, USACE must ensure that new fabricators meet AWS D1.5 code requirements and actively participate in the AISC Certification Program for Steel Bridge Fabricators or HYDA Fabricators with the Fracture Control Endorsement, (as required by AWS D1.5 Clause 12).
 - iii. The Engineer must include in the contract specifications any specific requirements that must be addressed in the FCP. Examples of specific requirements may include:
 - the prohibition of splices,
 - field welds, or
 - for individual components to be shop assembled before field installation.

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The Engineer must review the submitted FCP to ensure the contractor has addressed all fracture critical requirements, including:

- base metal,
 - welding consumable storage requirements and exposure limits,
 - preheat,
 - proper material handling requirements to prevent damage, and
 - testing requirements.
- iv. In accordance with AWS D1.5, Clause 12, and ER 1110-2-8157 requirements, the Engineer must approve all repairs to FCMs and fracture critical welds for new HSS. This ensures the Engineer is:
- reviewing and approving repairs,
 - verifying multiple repair cycles are not occurring on the same weld/member, and
 - being given the option to replace components in lieu of repair.

For typical repairs to FCM, the Engineer must approve a welding repair plan and WPS for repairs that incorporate additional preheat requirements and post heating to minimize the potential for hydrogen cracking, verify defect removal with MT, and verification of NDT following weld repair completion. For these reasons the Engineer must be available to perform shop visits during fabrication or must delegate these duties to qualified onsite QA staff.

- j. USACE has partnered with AISC to establish the certification category “Supplemental requirements for Hydraulic Fabricators (HYD, HYDA)” to ensure sufficient fabricators meet the technical requirements necessary to fabricate HSS according to Clause 12. A key requirement in AISC certification ensures that the head of the QC department reports to the owner of the company instead of the head of production. This requirement also ensures that the QC department maintains quality as the top priority.
- i. Additional AISC certification includes maintaining QC requirements such as:
- developing, documenting, and implementing an FCP,
 - annual training on FCP requirements,

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- welder performance qualification records (i.e., qualifying and maintaining “certified welders”),
- welding procedure specifications (both prequalified and qualified by testing),
- procedures for documenting nonconformances,
- procedures for ensuring EOR review and approval of all repairs or modifications, and
- capability to document bolt installation and testing in accordance with RCSC requirements.

AISC certified fabricators are accustomed to documenting these necessary requirements to meet ER 1110-2-8157.

- ii. Note that utilizing an AISC certified fabricator does not remove the requirement for USACE to perform QA in addition to the contractor’s required QC.
- k. The Engineer must prepare an engineering during construction (EDC) budget that addresses the required engineering involvement in QA and the necessary QA staff to perform the mandatory verification inspections. The budget must address QA activities, including:
- prefabrication conferences,
 - routinely scheduled meetings/progress meetings,
 - onsite QA in the fabrication shop, and
 - the hiring of QA personnel with the technical skills required to perform QA verification testing.

QA activities include the hiring of QA personnel who are Certified Welding Inspectors (CWIs), ASNT NDT technicians, and The Association for Materials Protection and Performance (AMPP) (Formerly NACE/SSPC) Certified Coating Inspectors.

- i. These services may require a contract with a third-party contractor or the utilization of QA personnel from the Welding and Metallurgy TCX.
- ii. The EDC budget must address engineering and QA support during and after delivery, field erection activities, and operational testing. Travel costs required for attending fabrication shop visits, meetings, and field installation visits must

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- be incorporated into the EDC budget to meet the requirements of ER 1110-2-8157.
- iii. As part of the QA process, the Engineer must be on-site for all erection, installation, and testing through completion of the contract. Modifications are often required during installation and testing, and the Engineer must be onsite for approving any modifications to the structure (as applicable).
- I. The Engineer is responsible for the following tasks during the fabrication phase of new HSS:
- shop drawing and submittal review and approval,
 - construction site visits,
 - review of Value Engineering (VE) proposals and contract modifications,
 - consultation on plans and specifications interpretation,
 - final inspection of completed HSS, and
 - the use of guide specifications.
- i. The quality of new fabrication must start at design and continue through fabrication and use of the HSS. QA for fabrication of new HSS is a team approach. As outlined in ER 1110-2-8157, the Engineer has a considerable role in performing QA for new HSS. In executing the requirements of ER 1110-2-8157, it is critical that the Engineer establish roles and responsibilities in close collaboration with Construction staff. It is also essential for the Engineer to become part of the QA team for the fabrication and erection of a new HSS.
 - ii. The Engineer must establish required witness points for inspection and ensure contractor QC and USACE QA is occurring throughout the fabrication process. UFGS 05 59 20 provides additional guidance within the notes of the guide specification and has been tailored to include the minimum submittals and testing required per ER 1110-2-8157.
 - a. Key requirements of ER 1110-2-8157 are included in Guide Specification 05 59 20, which amends the minimum requirements of AWS D1.5. These requirements include:
 - the use of a weld tracking log,
 - prohibition of tack welds located outside the weld zone,

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- mandatory NDT requirements,
- prohibition of splices without approval of the Engineer,
- an ultrasonic inspection written practice,
- the use of weld access holes,
- removal of backing bars,
- erection and installation plans,
- transport plans,
- handling requirements, and
- the sealing of welded components that will be submerged.

These additional requirements are necessary augments to AWS D1.5 such that new HSS meet the requirements of ER 1110-2-8157.

- b. The Engineer may include other requirements, such as additional welding inspection or verification testing, in the guide specifications.
- iii. Key submittals that must be reviewed and approved by the Engineer include:
 - a. Fabricator certification.
 - b. Shop drawings.
 - c. Welding Procedure Specifications*
*Note: This is for both prequalified and qualified welding by testing, which requires the Engineer to witness both the welding and testing of the procedure.
 - d. Welder qualification records (certified welders).
 - e. Certified Welding Inspector verification (including a primary inspector who maintains an AWS D1.5 endorsement).
 - f. Verification of ASNT CP-189 certified NDT technicians in PT, MT, UT, and RT (as required).
 - g. Review and approval of the FCP.
 - h. The work plan.

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- i. Assembly plan (including weld sequencing).
 - j. Ultrasonic testing written practice.
 - k. Delivery/shipping plan.
 - l. Weld tracking log.
 - m. Welding repairs for non-FCMs.
 - n. Welding repairs for FCMs.
 - o. Witness points.
 - p. Repair of mislocated holes.
 - q. Schedule of random testing.
 - r. Material certifications (mill certs).
 - s. Bolt installation sequence.
 - t. Bolt testing requirements.
 - u. Control dimensions.
- m. QC and QA requirements for field work are no different than the requirements for shop fabrication. Onsite QC and QA of fabrication are still mandatory. The contractor performing installation and field work is often not the same contractor who performed shop fabrication. A new set of submittals from the prime/field contractor associated with the welding requirements, including many of the submittals previously identified, will be required. This includes:
- welding procedure specifications,
 - certified welding inspectors,
 - ASNT NDT technicians,
 - field fracture control plan,
 - assembly plan, and
 - others (as applicable).

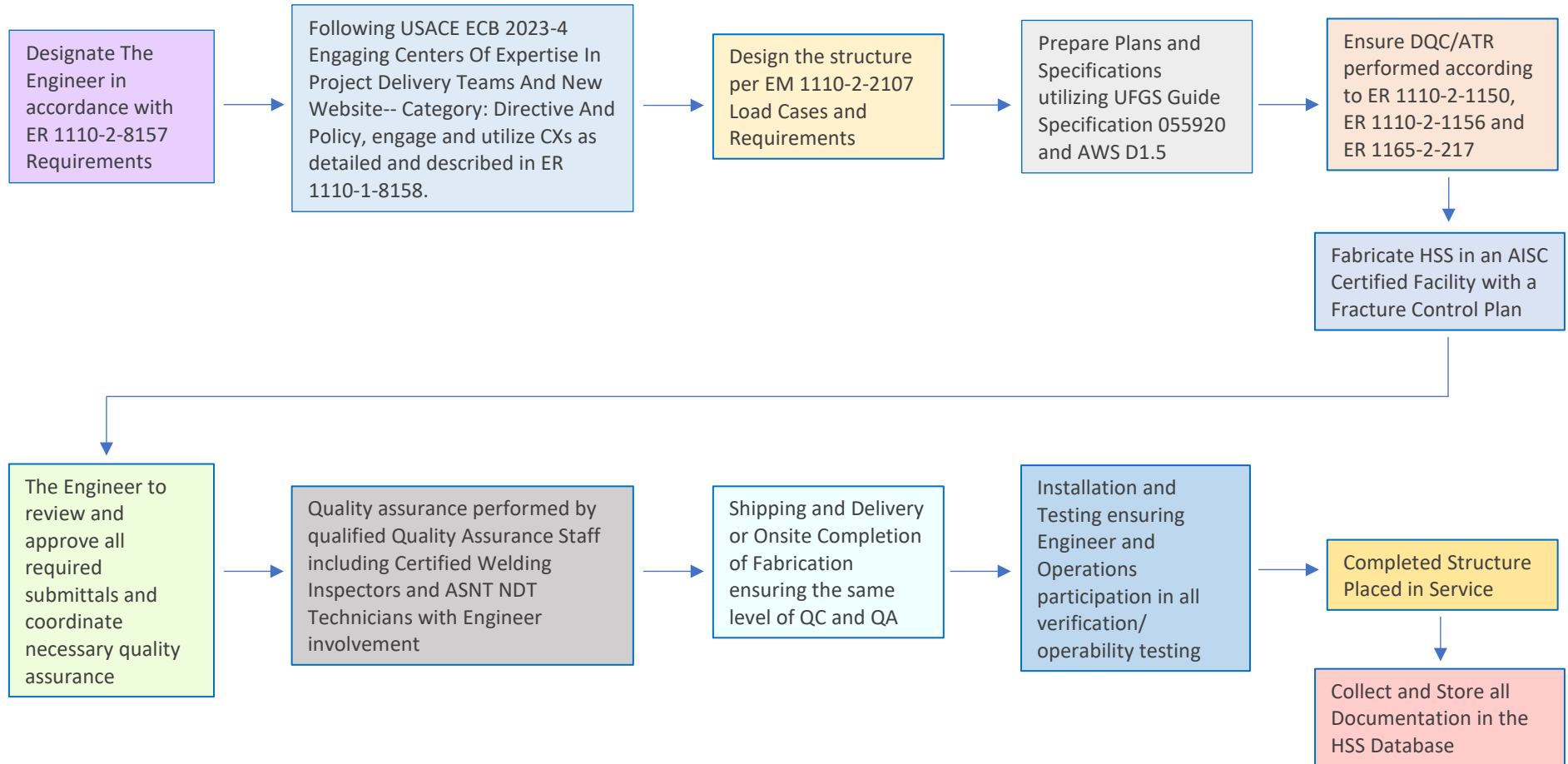
Considerable coordination is necessary to ensure QC and QA activities are occurring during installation and testing of the HSS.

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- n. Upon successful completion of all fabrication and NDT, the new HSS must then be certified as meeting all requirements per ER 1110-2-8157 before the new HSS is placed into service. The EOR must ensure that a permanent record of all HSS fabrication and required NDT documentation are stored in the HSS database. Use of the Walla Walla HSS database is encouraged.

Fabrication of New HSS Flow Chart



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ATTACHMENT B – REHABILITATION OF EXISTING HYDRAULIC STEEL STRUCTURES

ABBREVIATIONS

AASHTO	American Associate of State Highway and Transportation Officials
AISC	American Institute of Steel Construction
AMPP	The Association for Materials Protection and Performance
ANSI	American National Standards Institute
ASNT	American Society of Nondestructive Testing
ATR	Agency Technical Review
AWS	American Welding Society
CWI	Certified Welding Inspector
CX	Center of Expertise
DQC	District Quality Control
EDC	Engineering During Construction
EM	Engineering Manual
EOR	Engineer of Record
ER	Engineering Regulation
FCM	Fracture Critical Member
FCP	Fracture Control Plan
HDC	Hydroelectric Design Center
HSS	Hydraulic Steel Structure
INDC	Inland Navigation Design Center
MSC	Major Subordinate Command
MT	Magnetic Particle Testing
NDT	Nondestructive Testing
PDT	Project Delivery Team
PQR	Procedure Qualification Record
PT	Penetrant Testing (Dye Penetrant Testing)
QA	Quality Assurance
QC	Quality Control
RCSC	Research Counsel on Structural Connections
RFI	Request for Information
RMC	Risk Management Center
RMO	Review Management Organization
RT	Radiographic Testing
TCX	Technical Center of Expertise
USACE	U.S. Army Corps of Engineers
UT	Ultrasonic Testing
VE	Value Engineering
VT	Visual Testing (Visual Inspection)
WPS	Welding Procedure Specification

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The general steps below are necessary for rehabilitating existing HSS:

1. Rehabilitation of existing HSS is often required for extending the design life of the structure. Rehabilitation, in accordance with EM 1110-2-2107, must consider, at a minimum, all appropriate load cases outlined in the EM. Additional load cases may be considered based on actual loading experienced in use. The intent of rehabilitation is to ensure that all new appropriate load cases, or in-service loads being experienced by the structure, are being properly addressed.

The EOR must determine if the structure can be rehabilitated or if replacement is necessary. Many structures cannot be rehabilitated to meet EM load case requirements or to restore design life. The cost of rehabilitation, including risk associated with unknown/unidentified defects, often makes replacement the only viable option to meet EM and ER requirements. The EOR is responsible for making this determination.

- a. This includes fatigue evaluation to ensure sufficient life of the structure will be achieved after rehabilitation. Rehabilitating an existing structure to meet the 100-year design life requirements of EM 1110-2-2107 may not be possible. The extended design life of rehabilitated HSS must be identified by EOR and concurred with by appropriate Operations Manager in design documentation.
 - b. Required load cases must be evaluated using a risk-informed design philosophy that incorporates appropriate DQC and ATR requirements. It may not be possible to rehabilitate the existing structure to meet current EM 1110-2-2107 requirements. The structure must be evaluated through the entire load path, incorporating a holistic evaluation of all required components including structural, electrical, and mechanical operating systems.
2. Design HSS rehabilitation for appropriate review and approval, including, at a minimum:
 - a. All calculations performed and checked per ER 1165-2-217.
 - b. Selection and specification of the appropriate welding code, which is typically AWS D1.1 for existing structures.
 - c. Prior to designing rehabilitation, it is advisable to acquire material samples to verify mechanical properties of the steel. Material properties, including chemistry, yield strength, tensile strength, and elongation can be determined through lab testing.
 - i. The utilization of a 1.25" annular cutter (Hougen bit) in a magnetic based drill can remove 1.25" samples for testing. These samples can be subjected to sub-sized testing per ASTM A370 to provide mechanical properties used for rehabilitation design. The Engineer will need to identify the location of all

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- samples to be taken to ensure structural integrity remains (e.g., take samples from the neutral axis of the web of a girder or the skin plate above normal water line). Repair sample locations by installing a fully pretensioned F3125 grade A325 bolt.
- ii. Samples can typically be acquired by Operations staff then submitted for testing at a local lab via purchase order/credit card purchase.
 - iii. Instances of existing steel not meeting minimum yield or tensile strength requirements have occurred. Instances of substituted steel being present on an existing structure have also occurred. For these reasons, sampling the existing steel in multiple locations is always advisable prior to analyzing a structure for rehabilitation.
- d. Contract rehabilitation drawings that address rehabilitation modifications.
- e. Development of a plan to qualify welding by testing in accordance with code requirements. This is required when welding any non-approved base metal. Many existing USACE HSS were fabricated from base metal that is no longer produced or approved in welding codes. Further discussion of this can be found in EM 1110-2-6054.
- i. Many materials such as Fed Spec QQ-S-741A steel, ASTM A441 Steel, ASTM A373 Steel, and others are no longer produced and are not considered pre-approved base metals in AWS D1.1. The welding of these steels will typically require a sampling plan to identify the material based on chemistry and mechanical testing.
 - ii. Upon verification of the material, a procedure can be qualified by testing for the position and process of welding required to perform the repairs. This may necessitate more than one position or joint detail requirement for procedure qualification. The intent of this qualification is to ensure that the WPS followed for performing repairs will be successful to code without visual defects (e.g., porosity or lack of fusion) and will meet intended mechanical requirements for strength and ductility.
 - iii. The development of a WPS qualified by testing will require the EOR to identify locations where existing base metal can be removed from the structure to permit procedure qualification testing. Qualifying procedures by testing is used within AWS D1.1 and AWS D1.5 to increase the potential for successful welding or to minimize the risk of weld incompatibility being identified after production welding begins. The intent is to ensure welds are certified/qualified on sample plates/parts instead of the final production components (which minimizes the risk of unsuccessful welds occurring during repairs).

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- f. Establish fabrication rules for meeting minimum QC standards as required by ER 1110-2-8157.
 - g. QC plan if a Fracture Control Plan (FCP) is not being utilized.
 - h. FCP for the welding of Fracture Critical Members (FCM).
 - i. Welding consumable storage requirements and exposure limits.
 - j. Material handling requirements
For example: Avoid notches that may cause fracture by using softeners on FCM.
 - k. Material tracking requirements
For example: Mill-certification, soft stamping of components, etc.
3. Justifications for deviations and waivers from mandatory design standards in EM 1110-2-2107 must include a risk assessment. All deviations and waivers must be clearly identified in the decision documents and design reports and must be deliberately called out within the review plan as a specific charge for the review.

All proposed deviations and waivers from the mandatory design standards provided in EM 1110-2-2107, including rationale, must be documented in a memorandum approved by the respective District and Division Dam or Levee Safety Officer and concurred by the Dam or Levee Safety Oversight Group (DSOG or LSOG), whichever is appropriate. The DSOG or LSOG will ensure the appropriate USACE Community of Practice leader(s), or their designated representatives, are included in the concurrence process.

4. Rehabilitation of existing HSS not fabricated to current AWS D1.5 standards and UFGS 05 59 20 will require the Engineer to develop plans and specifications to address welding on existing steel structures that contain steels not considered pre-approved in current editions of either AWS D1.1 or D1.5.
- a. Note that there is currently no UFGS guide specification for rehabilitation of existing structures. A new UFGS guide specification for rehabilitation and repair of existing HSS will be authored. Presently, UFGS 05 59 20 should not be utilized for rehabilitation of existing structures without considerable modification of the specification.
 - b. Recently awarded rehabilitation projects used a modified version of UFGS 05 59 20 to identify necessary fabrication requirements to meet ER 1110-2-8157 requirements.
 - c. To meet ER 1110-2-8157 requirements, the rehabilitation of an existing HSS requires design and coordination with the EOR.

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5. ER 1110-2-8157 Section 9.b. “Modifications and Repairs” requires that, “all modifications and repairs to HSS and any modification or repair to an FCM must be designed by the Engineer...” The EOR must detail rehabilitation requirements to ensure all required QC and QA is properly performed and documented.

The designated EOR must design the rehabilitation and detail specific needs to ensure the requirements of ER 1110-2-8157 are being met. The criticality of the component needing rehabilitation will dictate the necessary technical requirements. Specific examples will be provided below regarding recommended practices. In general, the following steps must be taken for all HSS requiring rehabilitation:

- a. Designate the EOR per ER 1110-2-8157 requirements.
 - b. The EOR must design and analyze the required rehabilitation (e.g., member replacement, corrosion repairs, weld repairs) to meet EM 1110-2-2107 requirements.
 - c. Follow design review requirements in accordance with ER 1110-2-1150, ER 1110-2-1156, and ER 1165-2-217 *Civil Works Review Policy*, to ensure DQC and ATRs are completed for all structures. Ensure all review plans are coordinated through the appropriate RMO. The RMO for a structure must be determined according to ER 1165-2-217, Table 2.1. The RMO for a structure may be the RMC, INDC, HDC or any other mandatory center of expertise.
6. An FCP is required for all HSS according to ER 1110-2-8157. AWS D1.1 does not include an FCP. For this reason, the Engineer must author all requirements of the FCP within the specifications used for rehabilitation. Key portions of AWS D1.5, Clause 12, can be utilized in rehabilitation specifications to ensure proper QC occurs. The Engineer must specify in the contract specifications any specific requirements that must be addressed in the FCP. Examples of specific requirements may include:
 - the prohibition of splices,
 - field welds, or
 - for individual components to be shop assembled before field installation.

The Engineer must review the submitted FCP to ensure the contractor has addressed all fracture critical requirements, including:

- base metal,
- welding consumable storage requirements and exposure limits,
- preheat,

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- proper material handling to prevent damage, and
- testing requirements.

In accordance with AWS D1.5, Clause 12, and ER 1110-2-8157 requirements, the Engineer must approve all repairs to FCMs and fracture critical welds for new HSS. This ensures the Engineer is:

- reviewing and approving repairs,
- verifying multiple repair cycles are not occurring on the same weld/member, and
- being given the option to replace components in lieu of repair.

For typical repairs to FCM, the Engineer must approve a welding repair plan and WPS for repairs that incorporate additional preheat requirements and post heating to minimize the potential for hydrogen cracking, verify defect removal with MT, and verification of NDT following weld repair completion. For these reasons the Engineer must be available to perform shop visits during fabrication or must delegate these duties to qualified onsite QA staff.

7. In accordance with USACE ECB 2023-4 *Engaging Centers of Expertise (CX) in Project Delivery Teams and New Website-- Category: Directive and Policy* the Engineer must engage and utilize CXs as detailed and described in ER 1110-1-8158.

Typical CXs involved in HSS include (but are not limited to): Corrosion Control and Cathodic Protection TCX, Welding and Metallurgy TCX, and the Paint Technology Center CX.

8. The Engineer must prepare an Engineering During Construction (EDC) budget that addresses the required engineering involvement in QA and the necessary QA staff to perform required mandatory verification inspections. The budget must address QA activities, including:
 - prefabrication conferences,
 - routinely scheduled meetings/progress meetings,
 - onsite QA in the fabrication shop, and
 - the hiring of QA personnel with technical skills required to perform QA verification testing.

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QA activities include the hiring of personnel who are Certified Welding Inspectors (CWIs), ASNT NDT technicians, and The Association for Materials Protection and Performance (AMPP (formerly NACE/SSPC)) Certified Coating Inspectors.

- a. These services may require a contract to a third-party contractor or the utilization of QA personnel from the Welding and Metallurgy TCX.
 - b. The EDC budget must address engineering and QA support during and after delivery, field erection activities, and operational testing. Travel costs required to attend fabrication shop visits, meetings, and field installation visits must be incorporated into the EDC budget to meet the requirements of ER 1110-2-8157.
 - c. As part of the QA process, the Engineer must be on-site for all erection, installation, and testing required through completion of the contract. Modifications are often required during installation and testing, and the Engineer must be onsite to approve any required modifications to the structure (as applicable).
9. The Engineer is responsible for the following tasks during the rehabilitation phase of HSS:
- shop drawing and submittal review and approval,
 - construction site visits,
 - review of Value Engineering (VE) proposals and contract modifications,
 - consultation on plans and specifications interpretation,
 - final inspection of completed structures, and
 - the use of guide specifications.

Key submittals that must be reviewed and approved by the Engineer include:

- a. Fabricator certification.
- b. Shop drawings.
- c. Welding procedure specifications*
*Note: This is for both prequalified and qualified welding by testing, which requires the Engineer to witness both the welding and the testing of the procedure.
- d. Welder qualification records (certified welders).
- e. Certified Welding Inspector verification.

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- f. Verification of ASNT CP-189 certified NDT technicians in PT, MT, UT, and RT as required.
 - g. Review and approval of the FCP.
 - h. The work plan.
 - i. Assembly plan (including weld sequencing).
 - j. Ultrasonic testing written practice.
 - k. Delivery/shipping plan.
 - l. Weld tracking log.
 - m. Welding repairs for non-FCMs.
 - n. Welding repairs for FCMs.
 - o. Witness points.
 - p. Repair of mislocated holes.
 - q. Schedule of random testing.
 - r. Material certifications (mill certs).
 - s. Bolt installation sequence.
 - t. Bolt testing requirements.
 - u. Control dimensions.
10. The quality of rehabilitation must start at design and continue through fabrication and use of the structure. QA for fabrication of HSS is a team approach. As outlined in ER 1110-2-8157, the Engineer has a considerable role in performing QA for HSS. In executing the requirements of ER 1110-2-8157, it is critical for the Engineer to work closely with Construction staff to establish roles and responsibilities. It is also essential for the Engineer to become part of the QA team for the rehabilitation and erection of the HSS.
- a. The Engineer must establish required witness points for inspection and ensure contractor QC and USACE QA is occurring throughout the rehabilitation process. Key requirements of ER 1110-2-8157 that are included in guide specification 05 59 20, which need to be amended to address the welding of existing steel structures, include:

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- qualification of WPS utilizing existing base metal,
- the use of a weld tracking log,
- prohibition of tack welds located outside the weld zone,
- mandatory NDT requirements,
- prohibition of splices without approval of the Engineer,
- an ultrasonic inspection written practice,
- the use of weld access holes,
- removal of backing bars,
- erection and installation plans,
- transport plans,
- handling requirements, and
- the sealing of welded components that will be submerged.

These additional requirements are necessary to augment AWS D1.1 to ensure structures meet ER 1110-2-8157 requirements.

- b. The Engineer may include other requirements, such as additional welding inspection or verification testing, in the guide specifications.

11. Certified welders in the required welding process, position, and thickness must be utilized for all welding repairs. Welding performed to AWS D1.1 requirements must utilize welders who are qualified to AWS D1.1. This is an AWS Code requirement.

- a. In accordance with AWS D1.1, certification requirements include initial certification testing and verification of welding continuity with no breaks in use of the welding process greater than six months from initial certification.
- b. Initial certification and a continuity log showing no breaks in the process greater than six months must be reviewed by the EOR. Failure to provide required continuity will necessitate requalification of the welder.

12. QA requirements, in accordance with ER 1110-2-8157, include, at a minimum, the following testing:

QA requires 100% visual inspection of all welding to verify QC occurred. The EOR must determine the acceptance criteria for visual inspection. In general, the use of

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AWS D1.1, Table 8.1, “Visual Inspection Acceptance Criteria” (Cyclically Loaded Non-Tubular Connections) is appropriate to be used for VT, PT, and MT.

13. There must be 100% visual inspection of all welding by an AWS Certified Welding Inspector (CWI) before, during, and after all welding. Visual inspection of welding is a through-process that requires the CWI to ensure:

- proper materials are used,
- proper fit up,
- a WPS is being utilized,
- proper settings,
- proper preheat,
- interpass temperature, and
- other applicable requirements, as necessary.

The visual inspection of welds does not only occur after all welding is complete.

14. Additional NDT, as required to meet ER 1110-2-8157 requirements, including PT, MT, or UT must be performed by an ASNT CP-189 certified technician in the method of testing being used. The EOR must designate the acceptance criteria for ultrasonic testing as well. In general, the use of AWS D1.1, Table 8.3, “UT Acceptance-Rejection Criteria” (Cyclically Loaded Non-Tubular Connections in Tension) is the appropriate criteria for inspection.

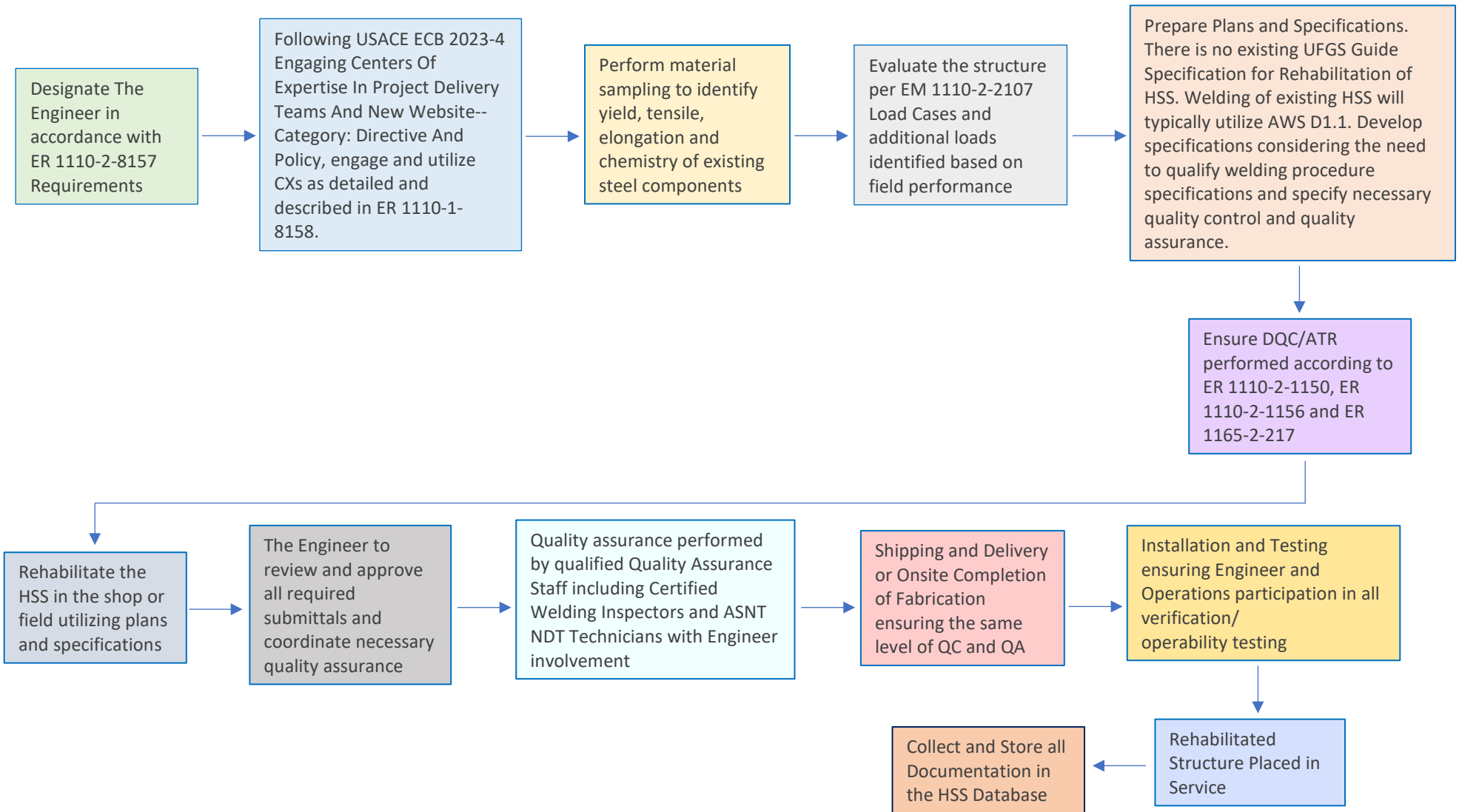
15. QA of welding (visual inspection and NDT) is an independent activity which must occur after all QC is complete. QA will typically require a third-party contractor or utilization of Welding and Metallurgy TCX QA staff.

16. Submit analysis and repair plan described above for DQC and ATR as appropriate. All designs require DQC and additional review. The need for additional ATR requirements and the use of DrChecks should be determined based on a risk-informed analysis of the required repairs.

17. Upon successful completion of all QC and QA, the EOR will certify the structure to confirm it meets ER 1110-2-8157 requirements.

18. The EOR will ensure a permanent record of all rehabilitation and required NDT documentation are stored in the HSS database. Use of the Walla Walla HSS database is encouraged.

Attachment B - Rehabilitation of Existing HSS Flow Chart



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ATTACHMENT C – REPAIR OF EXISTING HYDRAULIC STEEL STRUCTURES

ABBREVIATIONS

AASHTO	American Associate of State Highway and Transportation Officials
AISC	American Institute of Steel Construction
AMPP	The Association for Materials Protection and Performance
ANSI	American National Standards Institute
ASNT	American Society of Nondestructive Testing
ATR	Agency Technical Review
AWS	American Welding Society
CWI	Certified Welding Inspector
CX	Center of Expertise
DQC	District Quality Control
EDC	Engineering During Construction
EM	Engineering Manual
EOR	Engineer of Record
ER	Engineering Regulation
FCM	Fracture Critical Member
FCP	Fracture Control Plan
HDC	Hydroelectric Design Center
HSS	Hydraulic Steel Structure
INDC	Inland Navigation Design Center
MSC	Major Subordinate Command
MT	Magnetic Particle Testing
NDT	Nondestructive Testing
PDT	Project Delivery Team
PQR	Procedure Qualification Record
PT	Penetrant Testing (Dye Penetrant Testing)
QA	Quality Assurance
QC	Quality Control
RCSC	Research Counsel on Structural Connections
RFI	Request for Information
RMC	Risk Management Center
RMO	Review Management Organization
RT	Radiographic Testing
TCX	Technical Center of Expertise
USACE	U.S. Army Corps of Engineers
UT	Ultrasonic Testing
VE	Value Engineering
VT	Visual Testing (Visual Inspection)
WPS	Welding Procedure Specification

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The general steps below are necessary for repairing existing hydraulic steel structures (HSS):

1. Repair of existing HSS is often necessary to restore function to a structure either from damage or the result of inspection findings. Repairing a structure restores its function until rehabilitation or replacement can be executed. The District's Chief of Operations, in consultation with Operations' engineers, the Engineer of Record (EOR), and Water Management engineers must determine if the structure should be repaired or if restoring function can be deferred pending replacement.

Many structures cannot be easily repaired. The cost of repair, including risk associated with unknown/unidentified defects often makes replacement the only viable option to meet EM and ER requirements.

2. ER 1110-2-8157, *Responsibility for Hydraulic Steel Structures*, and EM 1110-2-6054, *Inspection, Evaluation, and Repair of Hydraulic Steel Structures*, will be amended to clarify these requirements for the repair of HSS. ER 1110-2-8157 will be amended to define the "who" associated with each responsibility for HSS including the District's Chief of Engineering, the EOR, the Chief of Operations, and others as applicable. Listing the "who" required to fund and perform each required activity will improve and clarify implementation of the requirements. The following repair requirements will be included in an update to ER 1110-2-8157 and EM 1110-2-6054 as funding is made available.
 - a. ER 1110-2-8157, Section 9.b. "Modifications and Repairs" requires "All modifications and repairs to HSS and any modification or repair to a FCM must be designed by the Engineer..." The EOR must detail repair requirements to ensure all required QC and QA is properly performed and documented. Operations must fund the Engineer and alert them to any required repairs before any repairs are performed. The need for repair may be identified by an engineering inspection or observations by Operations personnel. In either case, an EOR must detail these repairs. In accordance with ER 1110-2-8157, the Chief of Engineering must ensure the Engineer is available for all site visits necessary to perform the duties as required in support of Operations.
 - b. To meet ER 1110-2-8157 requirements, the repair of existing HSS requires design and coordination with the EOR. First, the Chief of Engineering (or Engineering Function for multi-function Divisions) must designate the EOR for each HSS. The requirements to be considered as the EOR for HSS are detailed in ER 1110-2-8157, paragraph 6.c.
 - c. The designated EOR must design the repair and detail specific needs to ensure the requirements of ER 1110-2-8157 are being met. The EOR must respond in a manner which reasonably meets the operational requirements for repair as provided by Operations. The criticality of the component needing repair will dictate the necessary technical requirements. Examples of typical procedures are

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provided below. In general, these steps must be taken for all HSS requiring repair.

3. Many existing HSS were fabricated prior to the adoption of ER 1110-2-8157 and UFGS 05 59 20 requirements and utilized older steels that do not meet AWS D1.5 requirements as a pre-approved base metal. The existing HSS typically do not incorporate ASTM A709 steel with required toughness. For newer structures fabricated to this guidance, repairs should utilize AWS D1.5 requirements. For existing structures that were not fabricated to AWS D1.5, the use of AWS D1.1 with increased QC and QA requirements is recommended.
4. Prior to designing repairs, verifying the mechanical properties of the steel by acquiring material samples is highly recommended. Material properties (including chemistry, yield strength, tensile strength, and elongation) can be determined through lab testing.
 - a. The utilization of a 1.25" annular cutter (Hougen bit) in a magnetic-based drill can remove 1.25" samples for testing. These samples can be subjected to sub-sized testing per ASTM A370 to provide mechanical properties used for the design of the required repair. The Engineer will need to identify the location of all required samples as that ensures structural integrity remains after sampling (e.g., take samples from the neutral access of the web of a girder or the skin plate above normal water line). Repair sample locations by installing a fully pretensioned F3125 Grade A325 Bolt.
 - b. Samples can typically be acquired by Operations staff then submitted for testing at a local lab via purchase order/credit card purchase.
 - c. Instances of existing steel not meeting minimum yield or tensile strength requirements have occurred. Instances of substituted steel being present on an existing structure have also occurred. For these reasons, sampling the existing steel in multiple locations is always advisable prior to analyzing a structure for repair.
5. The EOR must determine the appropriate repair by completing the following tasks:
 - a. Analysis of the cause for repairs.
 - b. Analysis to determine required repairs.
 - c. If analysis shows that repair is not possible the structure may need to be removed from service.
 - d. If analysis shows that repairs are possible, the EOR must design all repairs for appropriate review and approval to include, at a minimum:

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- i. All calculations performed and checked per ER 1165-2-217.
- ii. Selection and specification of the appropriate welding code, which will typically be AWS D1.1 for existing structures.
- iii. Required weld joint details to include selection of appropriate weld type (fillet, partial joint penetration groove, complete joint penetration groove).
- iv. Welding Procedure Specifications (WPS), including:
 - fit-up tolerances,
 - required preheat,
 - interpass temperature,
 - cooling rate,
 - post weld heat treatment, or
 - any other essential variable required (if considered prequalified per AWS D1.1).
- v. Fabrication shop drawings to be used by Operations staff or a contractor for performing required repairs.
- vi. Development of a plan to qualify welding by testing in accordance with code requirements. This is required when welding any non-approved base metal. Many existing USACE HSS were fabricated from base metal that is no longer produced or approved in welding codes. Further discussion of this can be found in EM 1110-2-6054.
 - (a) Many materials such as Fed Spec QQ-S-741A steel, ASTM A441 steel, ASTM A373 steel, and others are no longer produced and are not considered pre-approved base metals in AWS D1.1. The welding of these steels will typically require a sampling plan for identifying the material based on chemistry and mechanical testing.
 - (b) Upon verification of the material, a procedure can be qualified by testing for the position and process of welding required to perform the repairs. This may require more than one position or joint detail requirement for procedure qualification. The intent of this qualification is to ensure that the WPS followed for performing repairs will be successful to code without visual defects (e.g., porosity or lack of fusion) and will meet the intended mechanical requirements for strength and ductility.

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- (c) The development of a WPS qualified by testing will require the EOR to identify locations where existing base metal can be removed from the structure to permit procedure qualification testing. Qualifying procedures by testing is used within AWS D1.1 and AWS D1.5 to increase the potential for successful welding or to minimize the risk of weld incompatibility being identified after production welding begins. The intent is to ensure welds are certified/qualified on sample plates/parts instead of the final production components (which minimizes the risk of unsuccessful welds occurring during repairs).
- (d) A risk-informed design approach will be utilized when selecting the need to qualify a WPS by testing. In some instances, it is possible to author a repair procedure not requiring a WPS qualified by testing, provided certain essential variables can be controlled.

For example, the pitting repair of a Tainter Gate skin plate could be accomplished on older Fed Spec or ASTM steels with the use of SMAW welding with 70ksi low hydrogen electrodes incorporating proper increased preheat and techniques to slow the cooling rate of the repairs to minimize the potential for hydrogen cracking to occur. Prescriptive repair plans that verify steel materials, carbon equivalency and increased heating/cooling requirements in accordance with the Annexes of AWS D1.1 may be sufficient to ensure proper repairs on a non-fracture critical skin plate. Note, however, that a WPS is always required in instances of repair.
- vii. Develop a weld sequencing plan (for minimizing distortion).
- viii. Establish fabrication rules for meeting minimum QC standards as required per ER 1110-2-8157.
- ix. QC plan if a Fracture Control Plan (FCP) is not being utilized.
- x. FCP for the welding of Fracture Critical Members (FCM).
- xi. Welding consumable storage requirements and exposure limits.
- xii. Material handling requirements
For example: Avoid notches that may cause fracture by using softeners on FCM.
- xiii. Material Tracking Requirements
For example: Mill-certification, soft stamping of components, ...etc.
- e. Certified welders in the required welding process, position, and thickness must be utilized for all welding repairs. Welding repairs performed to AWS D1.1

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requirements must utilize welders who are certified to AWS D1.1. This is an AWS Code requirement.

- i. In accordance with AWS D1.1, certification requirements include initial certification testing and verification of welding continuity with no breaks in the welding process greater than six months from initial certification.
 - ii. Initial certification and a continuity log showing no breaks in the process greater than six months must be reviewed by the EOR. Failure to provide required continuity will necessitate requalification of the welder.
6. There must be 100% visual inspection of all welding by an AWS Certified Welding Inspector (CWI) before, during, and after welding. Visual inspection of welding is a through-process inspection that requires the CWI to ensure:
- proper materials are used,
 - a WPS is being utilized,
 - proper fit up,
 - proper settings,
 - proper preheat,
 - interpass temperature, and
 - other applicable requirements, as necessary.

The visual inspection of welds does not only occur after all welding is complete.

The EOR must determine the appropriate acceptance criteria for visual inspection. In general, the use of AWS D1.1, Table 8.1, “Visual Inspection Acceptance Criteria” (Cyclically Loaded Nontubular Connections) is appropriate to be used for VT, PT, and MT.

7. Additional NDT (as required) to meet ER 1110-2-8157 requirements, including PT, MT, or UT, must be performed by an ASNT CP-189 certified technician in the required testing method. The EOR must identify the NDT acceptance criteria (including UT). In general, the use of AWS D1.1, Table 8.3, “UT Acceptance-Rejection Criteria” (Cyclically Loaded Nontubular Connections in Tension) is appropriate criteria for inspection.

QC requirements may require a third-party inspection contract if ASNT certified technicians are not available through existing staff resources.

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8. QA of welding (visual inspection and NDT) is an independent activity which must occur after all QC is complete. QA will typically require a third-party contractor or utilization of the Welding and Metallurgy TCX QA staff.
9. Submit analysis and repair plan described above for DQC and ATR as appropriate. All designs require DQC and additional review. The need for additional ATR requirements and the use of DrChecks should be determined based on a risk-informed analysis of the required repairs.
10. The EOR must serve as part of the QA team and will need to be onsite prior to, during, and after all weld repairs to ensure QC and QA has occurred.
11. Upon successful completion of all QC and QA, the EOR will certify the structure to confirm it meets ER 1110-2-8157 requirements.
12. The EOR will ensure a permanent record of all repairs and required NDT documentation are stored in the HSS database. Use of the Walla Walla HSS database is encouraged.

Attachment C - Repair of Existing HSS Flow Chart

