SUPPLEMENT TO STANDARD
OPERATION AND MAINTENANCE MANUAL

SACRAMENTO RIVER
FLOOD CONTROL PROJECT

UNIT No. 148

WEST LEVEE OF FEATHER RIVER FROM
NORTH BOUNDARY OF LEVEE DISTRICT No. 9
TO
NORTH BOUNDARY OF LEVEE DISTICT No. 1

US Army Corps
of Engineers®

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

March 2016 - **DRAFT**

SUPPLEMENT TO STANDARD
OPERATION AND MAINTENANCE MANUAL
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UNIT No. 148

WEST LEVEE OF FEATHER RIVER
FROM NORTH BOUNDARY OF
LEVEE DISTRICT No. 9
TO NORTH BOUNDARY OF LEVEE DISTRICT No. 1

LOCATION	ADDITION OR REVISION	DATE
Supplemental Manual	This entire supplemental manual was revised to reflect the new format, as well as the improvements made to the levee as part of Project C of the Feather River West Levee Project (FRWLP). For historical reference, the previous supplemental manual text and previous revisions can be found in Appendix N.	March 2016

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SECTION 1 GENERAL

1-01. This Supplement to the Standard Operation and Maintenance (O&M) Manual has been prepared in accordance with the guidelines contained in the U.S. Army Corps of Engineers' (USACE) Engineering Regulation ER 1110-2-401, "*Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual for Projects and Separable Elements Managed by Project Sponsors*."

1-02. The levee of Unit No. 148 provides direct protection to the towns of Gridley, Live Oak and Yuba City, adjacent agricultural lands and against flood waters of the Feather River.

1-03. The flood-control improvement covered by this manual is a part of the Sacramento River Flood Control Project (SRFCP) authorized by the Flood Control Act of 1917 as modified by the Acts of 1928, 1937, and 1941, and consists of the west levee of the Feather River from the north boundary of Levee District No. 9 (RD 9) to the north boundary of Levee District No. 1 (LD 1) as shown on Exhibits 1 and 2.

1-04. The grade of the adopted floodplain profile along the main channel of the Feather River varies from elevation 92.0 at the north boundary of LD 9 to elevation 82.38 at the north boundary of LD 1 (elevations are referred to USACE datum). This reach of the Feather River has a project design capacity of 210,000 cubic feet per second, and the levee provides for a freeboard of at least three feet above the adopted floodplain profile within the unit.

1-05. Environmental compliance and mitigation requirements are briefly described in Section 10-05 of this Supplement and in Appendix K.

SECTION 2 AUTHORIZATION

2-01. See Standard O & M Manual for the authorization for the Sacramento River Flood Control Project.

2-02. Unit No. 148 of the SRFCP was initially built by local interests and later re-constructed to project grade and section by the USACE. Responsibility for operating and maintaining the completed works of Unit No. 148 was officially accepted by the Reclamation Board of the State of California (now known as the Central Valley Flood Protection Board (CVFPB)) on December 18, 1951 as shown on the letter of acceptance in Appendix G.

2-03. Flood and Coastal Storm Emergencies Act, Public Law 84-99.

2-04. Fiscal Year 1997 Emergency Supplemental Appropriations Act, Public Law 105-18.

2-05. Bank protection work was authorized by the Flood Control Act of 1960.

2-06. Work for Project C was administratively authorized by 33 U.S.C. Section 408 permission dated July 19, 2013 and CVFPB Permit No. 18793-1BD.

SECTION 3 LOCATION

3-01. The improvement covered by this manual is that part of the SRFCP which includes the west levee of the Feather River from the north boundary of LD 9 to the north boundary of LD 1. In general, the west levee of this unit extends from a point opposite the mouth of Honcut Creek to the Union Pacific Railroad (UPRR) crossing of the Feather River approximately two miles upstream from Yuba City. The levee of this unit is located in LD 9, in Sutter County, California and in the general vicinity between the towns of Live Oak and Yuba City. This manual supersedes Supplemental Manual No. 4 entitled, "West Levee of the Feather River in Sutter and Butte Counties, California, from two miles north of Yuba City northerly twelve miles".

3-02. Appendix B contains maps and aerial photos of the LD 9 boundaries and the alignment of the West Levee of the Feather River, Unit No. 148 that depict improvements made to Unit 148 as part of Project C. There are 9.92 ~~levee~~ Levee ~~miles~~ Miles (LM) within this unit.

SECTION 4 PERTINENT INFORMATION

4-01. Overview of Recent Improvements to Unit 148

As part of the Feather River West Levee Project (FRWLP), soil-bentonite (SB) and soil-cement-bentonite (SCB) cutoff walls were constructed at the levee centerline in order to reduce the hydraulic gradient and seepage flows to acceptable levels in accordance with USACE requirements. The installation of the cutoff wall required the removal of the top half of the existing levee, installation of the cutoff wall to various depths below the levee degrade elevation, and then the reconstruction of the top half of the levee. The levee was fully degraded for 600 linear feet beginning at ~~Levee Mile (~~LM~~)~~ 6.11 in the vicinity of Paseo Road. The southern extent of the cutoff wall begins at LM 0.07, located approximately 500 feet north of the UPRR crossing and approximately 80 feet north of an existing, 16-inch diameter Pacific Gas and Electric Company (PG&E) gas line, and extends north to LM 9.33 located approximately 0.6 miles south of the north limit of Unit 148. LM 0.00 corresponds to the southern limit of Unit 148 as shown in Appendix B, Exhibit 2.

The excavation limits for the levee degrade and corresponding elevation for the top of the cutoff wall varies from elevation 77.0 feet at LM 0.07 to elevation 90.0 feet at LM 9.33. The depth of the cutoff wall extending below the levee degrade elevation varies considerably along the length of the cutoff wall, with a minimum depth of 29 feet to a maximum depth of 120.5 feet. The intermediate elevations and locations of grade breaks for the levee degrade and depth of the cutoff wall are shown on the as-built drawings for the FRWLP, Project C, Volumes 3 and 4, located in Appendix C. The levee improvements beginning at the southern limit of Unit 148 are shown in Volume 3, Sheet C-130 of the as-built drawings.

Improvements or modifications to levee penetrations for pipes and levee encroachments were also completed as part of the FRWLP. Table P-1 in Appendix P lists pipeline penetrations for Unit 148. Table P-2 in Appendix P includes other encroachments for Unit 148.

4-02 Design Water Surface Elevation

As part of the FRWLP, the levee and appurtenant flood control systems were improved. The design water surface elevation was developed by Peterson Brustad, Inc. (PBI) using the USACE Common Features hydraulic model, version 3 (2011). It should also be noted that the FRWLP did not change the authorized design profiles or flows of the federal project.

a. Top-of-Levee
The design water surface elevation was used as the basis for determining the minimum top-of-levee elevation. During design, it was determined that the existing levee had more than three feet of freeboard the design water surface elevation at all locations for Unit 148.

b. Seepage and Slope Stability
Seepage and slope stability were analyzed at four feet above the 200-year water surface elevation in accordance with USACE EM 1110-2-1913. Where this exceeded the actual top-of-levee, the elevation at the physical top-of-levee was used. Exit gradients were limited to the following values:

- Landside levee toe: < 0.5
- Toe of seepage berm: < 0.8
- Landside levee toe with seepage berm: < 0.5 (between relief wells)
- Landside levee toe with relief wells: < 0.5
- Bottom of empty ditch at landside toe: < 0.5
- Bottom of empty ditch 150 feet or more from landside toe: < 0.8

4-03 Borrow Material

The levee improvements were constructed using existing levee embankment material and approximately 180,000 cubic yards of imported embankment material which met the requirements of the USACE Engineering Manual EM 1110-2-1913, "*Design and Construction of Levees,*" the Sacramento USACE District Standard Operating Procedure SOP-EDG-03, "*Geotechnical Levee Practice,*" and the *California Code of Regulations, Title 23*. Borrow material was obtained from the North Valley Borrow Site, which is located on the south side of Ella Avenue, approximately 0.6 miles east of Feather River Boulevard, Olivehurst, California. See Exhibit 1 in Appendix B for the location of the North Valley Borrow Site.

4-04 Right-of-Way Acquisitions

In general, land was acquired in fee title for the entire levee footprint (landside levee toe to waterside levee toe). In addition to acquiring land for the levee footprint, fee title was also generally obtained 20 feet beyond the landside toe, and 15 feet beyond the waterside toe. Finally, an easement was obtained 10 feet beyond the landside toe fee title acquisition, which resulted in a total of 30 feet of fee and easement acquisitions on the landside. See Exhibit 3 in Appendix B for an overview of the right-of-way that was acquired as part of Project C.

4-05 Datum

Elevations in this manual come from the United States Engineering Datum (USED), the National Geodetic Vertical Datum of 1929 (NGVD 29), and/or the North American Vertical Datum of 1988 (NAVD 88). Conversion factors between these datums is shown in the table on the following page.

Table 4-1 Datum Conversion Factors

To Convert From This Datum	Approximate Adjustment Factor To Convert To This Datum		
	USED	NGVD 29	NAVD 88
USED	-	- 3.0	- 0.72
NGVD 29	+ 3.0	-	+ 2.28
NAVD 88	+ 0.72	- 2.28	-

SECTION 5 CONSTRUCTION HISTORY

5-01. Unit No. 148 of the flood control works described in this manual forms an integral part of the Sacramento River Flood Control Project. Construction necessary to bring locally built levees of this unit to project standards was accomplished under the following contracts:

a. Enlargement of the west levee along the Feather River in LD 9 from Station 952 + 00 to Station 1380 + 00 as shown on Drawing No. 4-4-135, sheets 1 and 2 of Exhibit B, was constructed under Contract No. W-1105-eng-1341 by Hass, Doughty & Jones, contractors, and completed on 23 August 1934.

b. Enlargement of the west levee of the Feather River from UPRR (formerly S.P.R.R.) two miles north of Yuba City northerly 12 miles, was constructed under Contract No. W-04-167-eng-605 by H. Earl Parker, contractor. Work on this contract was started on 16 August 1944 and completed on 25 September 1945 (see Exhibit B, Drawing No. 50-4-2193, sheets 1 to 6 incl. and Drawing No. 4-4-267 for details).

c. Berm fill, drainage ditch and road approaches on the west levee of the Feather River eight miles north of Yuba City were constructed under Contract No. W-04-167-eng-1345, by H. Earl Parker, contractor and completed on 9 January 1948. (see Exhibit B Drawing No. 4-4-292, Part "C" for details).

d. Levee degrade, installation of soil bentonite and soil cement bentonite cutoff walls, and the modification of levee penetrations for the reach of levee extending from LM 0.07 to LM 9.33 were constructed under Contract No. 01-2013C (408 Permission for the Feather River West Levee Project Area C, dated September 16, 2013), by Nordic / Manus Pacific Joint Venture, and completed on August 1, 2015. See as-built construction drawings for the FRWL Project, Volumes 3 and 4 in Appendix C for details. The levee improvements, beginning at the southern limit of Unit 148, are shown on Volume 3, Sheet C-130 of the drawings.

SECTION 6 PROJECT PERFORMANCE

6-01. As constructed, the levee height provides for a freeboard of at least ~~3~~ three feet above the adopted floodplain profile.

6-02. If the levee capacity is exceeded or fails, flooding occurs in the Sutter Basin, which includes a portion of Sutter and Butte Counties; the city of Yuba City; the towns of Live Oak and Gridley; and adjacent agricultural areas.

6-03. Flood Flows. For purposes of this manual, the term "flood" or "high water period" shall refer to flows when the water surface in the Feather River reaches or exceeds the reading of 95.0 (USED) on the Department of Water Resources continuous water stage recorder and staff gage located on the east side (left bank) of the Feather River on the downstream side of the abutment of bridge on Gridley-Oroville Road two and one-half miles east of Gridley, and/or when the water surface reaches or exceeds a reading of 65.0 on the Department of Water Resources continuous water stage recorder and staff gage located near the right bank of the Feather River on downstream side of the Sacramento Northern Railroad Bridge at Yuba City. ~~Gages are set on U. S. Corps of Engineers datum.~~

SECTION 7 PROJECT COOPERATION AGREEMENT

7-01. Assurance of cooperation by local interests is provided by s~~S~~tate legislation and contained in Chapter 3, Part 2, Division 5 of the State Water Code (see paragraph 2-02a of the Standard Manual).

7-02. Acceptance by State Reclamation Board.

Responsibility for operating and maintaining the completed works was officially accepted by the Reclamation Board of the State of California on 18 December 1951, as shown on the letter of acceptance in Appendix G. Copies of the letters of acceptance for operation and maintenance of subsequent modifications to the completed works are~~is~~ also included in Appendix G.

7-03. Superintendent. The name and address of the Superintendent appointed by local interests to be responsible for the continuous inspection, operation, and maintenance of the project works shall be furnished to the District Engineer~~;~~ and, in case of any change of Superintendent, the District Engineer shall be so notified.

SECTION 8 OPERATION

8-01. Operation of the improved levees is to be carried out in the same manner as the existing levee system was operated prior to the improvements.

8-02. Slide gates and other positive closure devices on irrigation pipelines penetrating the levee should be closed at the conclusion of the irrigation season and confirmed to be closed during each routine patrol during the flood season.

8-03. See Section 10 for maintenance and inspection requirements for Unit 148.

SECTION 9 EMERGENCY OPERATIONS

9-01. Emergency surveillance, communication, and chain of responsibility for the Unit No. 148 levees and associated infrastructure are to be under existing protocols of the Superintendent, under the supervision of the California Department of Water Resources.

9-02. The emergency operations are as recommended in Section VIII of the USACE's *"Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project, revised 1955."* (Standard O&M Manual).

9-03. Repair of Damage. In the event of serious damage to the project works, whether due to flood conditions or other causes, and which may be beyond the capability of local interests to repair, the Superintendent will contact a representative of the Department of Water Resources, State of California, who coordinates maintenance of project works of the Sacramento River Flood Control Project. The state representative will give assistance or advice, or will determine appropriate action to be taken.

9-04. Applicable Methods of Combating Floods. For applicable methods of combating flood conditions, reference is made to Section VIII of the Standard O&M Manual, where the subject is fully covered.

9-05. Slide Gate Operation. Positive closures on irrigation pipelines should be checked and confirmed to be closed at each routine patrol during the flood season. During emergency high water events, positive closures on other utilities need to be closed. Positive closures on interior drainage pipelines shall be closed on a case-by-basis as determined by the Superintendent.

9-06. Monitoring of the System. Particular attention should be given to monitoring the performance of the levees during high water events to ensure that the improvements function as designed. Attention should be given to any cracking or slumping of the slopes or crown.

Groundwater levels should be monitored via the monitoring wells installed between LM 0.02 and LM 0.09 during high water levels. The monitoring wells contain a pressure transducer and are connected to centralized data loggers. The data loggers will transmit information via telemetry to the California Data Exchange Center (CDEC) where this data can be retrieved ~~from~~ http://cdec.water.ca.gov~~/~~.

Standard flood-fighting techniques should be employed during high water events, and observed problem areas should be addressed promptly. Proper response during high water conditions will include measures to prevent erosion and promptly repair wave wash and scour damage. Typical flood fighting methods will include the following:

a. High water patrolling and reporting of trouble spots;

b. Wave wash protection of eroded slopes;

c. Caving bank protection;

d. Scour hole repair;

e. Topping of low or eroding spots on the levee crown using sandbags, lumber and sack, or mud box bulkhead construction;

f. Flood barrier construction;

g. Sandbagging to control boils that are issuing sediment;

h. Brushing and sacking the landside levee slope; and

i. Draining the landside levee slope.

9-07. Other references include:

a. "*Design and Construction of Levees*," U.S. Army Corps of Engineers, EM 1110-2- 1913, 30 April 2000; and.

b. A good summary of flood-fighting methods is contained in the DWR publication entitled, "*Flood Fighting Methods*," dated August 2010. This publication is included as Appendix D for reference.

SECTION 10 MAINTENANCE AND INSPECTION

10-01. Levee

a. Description. The levee described in this manual is located along the westerly side of the Feather River from the north boundary of LD 9 to the north boundary of LD 1. The levee within this unit was originally built by local interests and later re-constructed to project grade and section by the USACE, as previously described.

b. For pertinent Requirements of the Code of Federal Regulations and other requirements, see the following:

1) Maintenance – paragraph 4-02 of the Standard Manual.

2) Check Lists – Appendix E of this Supplement to the Standard Manual.

3) Operation – paragraph 4-04 of the Standard Manual.

4) Special Instructions – paragraph 4-05 of the Standard Manual.

c. Environmental Values. Vegetation preserved as a part of selective clearing on the waterside berm of slope above the bank protection during the prosecution of bank protection contracts shall not be removed as a part of normal maintenance as long as it remains alive and in a healthy state.

d. Maintenance of cutoff walls: Modification or repair work in the vicinity of the SB or SCB cutoff wall should include provisions to avoid damaging the cutoff wall. The cutoff wall acts as an impervious barrier and shall not be penetrated at any point along its length or depth. Proposed future utilities shall be placed over the existing cutoff wall.

10-02. Drainage and Irrigation Structures.

a. Description. A list of penetrations encountered as part of Project C is included as Appendix R in this Supplement.

b. For pertinent Requirements of the Code of Federal Regulations and other requirements, see the following:

1) Maintenance – paragraph 5-02 of the Standard Manual.

2) Check Lists – Appendix E and F of this Supplement to the Standard Manual.

3) Operation – paragraph 5-04 of the Standard Manual.

4) Additional Requirements – paragraph 5-05 of the Standard Manual.

5) Safety Requirements – paragraph 5-06 of the Standard Manual.

10-03. Channel.

~~a.~~ Description. The low water channel of the Feather River within this unit meanders along a comparatively wide overflow area which is confined between the east and west levees of the Feather River from the north boundary of LD 9 (near the mouth of Honcut Creek) to the north boundary of LD 1 (about two miles north of Yuba City). The channel within this reach has a project design capacity of about 210,000 cubic feet per second. The overflow channel within this area contains considerable tree growth and open agricultural areas adopted for seasonal crops.

~~b.~~a. The maintenance and operation of the channel of the Feather River within this unit shall be limited to flood control and the requirements which follow, and shall be observed only to that extent

~~c.~~b. For pertinent Requirements of the Code of Federal Regulations and other requirements see the following:

1) Maintenance – paragraph 6-02 of the Standard Manual.

2) Check Lists – Exhibit E of this Supplement to the Standard Manual.

3) Operation – paragraph 6-04 of the Standard Manual.

4) Safety Requirements – paragraph 6-05 of the Standard Manual.

~~d.~~c. It shall be the duty of the Superintendent to maintain a patrol of the project works during all periods of flood flow in excess of a reading of 95.0 on the gage at Gridley Bridge or a reading of 65.0 on the gage at Yuba City as indicated in paragraph 1-05 of this manual. The Superintendent shall dispatch a message by the most suitable means to the District Engineer whenever the water surface at Gridley Bridge or at Yuba City reaches the gage readings indicated above. The Superintendent shall cause readings to be taken at said gages at intervals of two to four hours during the period when the water surface is above the flood-flow stages indicated above and record the time of the observations. One copy of the readings shall be forwarded to the District Engineer immediately following the flood, and a second copy transmitted as an enclosure to the semi-annual report in compliance with paragraph 3-06 of the Standard Manual.

10-04. Miscellaneous Facilities.

a. Description. —Miscellaneous structures or facilities which were constructed as a part of, or existed in conjunction with, the protective works, and which might affect their functioning, include the following:

1) Bridge. None.

2) Buried Utility Relocations or Modifications.

a) A portion of the 16-inch Singh irrigation pipe was removed and replaced with a raised pipe at LM 1.83.

b) A portion of the 20-inch Micheli storm drain pipe was replaced with a 20-inch raised pipe at LM 3.45.

c) A portion of the 36-inch Sunset Pump Station discharge pipe was replaced with a 36-inch pipe through the cutoff wall at LM 5.64.

d) A portion of two, 60-inch Sunset Pump Station discharge pipes was replaced with two, 60-inch pipes through the cutoff wall at LM 5.64.

e) The existing LD 9 Storm Drain pipe was replaced with a 36-inch gravity pipe at LM 9.06.

3) Hydrographic Facilities. Provisions have been made at several locations in the vicinity of this unit for hydrographic facilities. These facilities are to be maintained by the following agencies:

a) U. S. Weather Bureau station of the Feather River Bridge on the Oroville-Chico Highway.

b) Department of Water Resources station on the left bank of Feather River on an abutment of the bridge on Gridley-Oroville Road.

c) Department of Water Resources station on Feather River on the downstream side of the Sacramento Northern Railroad Bridge at Yuba City.

4) Relief Wells

a) Maintenance: The nine (9) relief wells located from LM 0.00 to LM 0.11 will require maintenance to ensure continuous proper

functioning. Relief wells will need to be maintained per EM-1110-2-1914.

b) Inspection: The relief wells shall be inspected annually to verify that they are functional and that no conditions exist that would prevent them from operating as intended in the future. Annual inspections shall be planned immediately prior to yearly high flows and additional inspections may be warranted during unusually high flows. The inspection shall include an examination of the structure, piping, gaskets, and flanges inside each manhole for unauthorized use, vandalism, or other irregularities.

Any items that are malfunctioning or have been damaged shall be replaced. Each relief well shall be sounded to determine whether sediment or other debris have been deposited in the wells. All wells requiring sediment removal shall be pump tested afterward to ensure the well efficiency has not decreased appreciably due to the presence of foreign material in the well.

Relief well access points shall be maintained so that cover plates can be easily removed for inspection of the tees and surrounding piping. The outfall structures shall be kept clear of debris or other material that may affect the operation of the outlet pipe flap gates.

c) Testing: The relief wells should be pump tested on a regular basis using the procedures outlined in USACE EM 1110-2-1914, Chapter 8. The purpose of these tests is to measure the efficiencies and flow capacities of the wells. Pump tests shall be performed every five years.

During pump tests, runoff shall be directed through the lateral pipes toward the outfall structures in order to ensure that the lines are free of blockages and the flap gates function properly. Sediment amounts in the relief wells shall be measured by sounding the well before and after pump tests. If significant algae or other biological growth is suspected within the well, the well shall be cleaned as described in Section 12-04 of this Supplement. If efficiencies are less than 80% of those recorded at the time of installation, corrective measures per USACE EM 1110-2-1914, Chapters 10 and 11 shall be employed. If corrective measures are implemented but do not improve performance to at least 80% of the original efficiency, replacement of the inefficient well(s) should be considered.

d) Evaluation: The measurements obtained during pump tests should be evaluated in accordance with EM1110-2-1914 in order to evaluate the performance of the well.

e) Record Keeping: Records shall be kept of all inspection and maintenance of the relief wells. Data shall include pump test information, general maintenance records, and summaries of observed relief wells flows during high water events.

5) Monitoring Wells

The three (3) monitoring wells located from LM 0.02 to LM 0.10 shall be maintained as needed to ensure that they can collect and transmit groundwater levels data during high water events.

10-05. Recreation Area

a. Description. The recreation area located at Pennington Road at LM 7.63 that includes a boat launching ramp, a parking area and landscaping shall be administered and maintained in a manner consistent with good public park practices. Inspection of the premises shall be conducted at least annually by members of the ~~Corps of Engineers~~USACE and the State Reclamation Board, on a mutually agreed-upon schedule, in order to determine the adequacy of the operation and maintenance program.

b. For pertinent Requirements of the Code of Federal Regulations and other requirements see the following:

1) Maintenance – paragraph 7-02 of the Standard Manual.

2) Check Lists – paragraph 7-03 of the Standard Manual.

3) Operation – paragraph 7-04 of the Standard Manual.

SECTION 11 SURVEILLANCE

11-01. See Section 10, Maintenance and Inspection for required project surveillance.

11-02. Post-construction differential settlement, cracking, and small slips could take place along the levee. Observations of any cracking, differential settlement, or slips shall be recorded and reported to a qualified engineer, DWR representatives and USACE personnel. Applicable remediation measures shall be developed to correct normal and abnormal distress issues that may be encountered.

11-03 Relief Wells: Flow quantities shall be measured at times during which the wells have been functioning. Flow quantities shall also be checked approximately one week after a peak occurs in the river level.

In addition, the ground area adjacent to the levee shall be checked for wet spots that are indicative of malfunctioning relief wells and for resulting seeps through the underlying clay blanket. The outfall structures shall be inspected for general condition and cleared of debris. Flap gates on outlet pipes shall be inspected to ensure free rotation about their hinges.

11-04 Information will be added to future drafts of this O&M Supplement for levee instrumentation.

SECTION 12 REPAIR, REPLACEMENT, AND REHABILITATION

12-01. Repair is considered to entail those activities of a routine nature that maintain the project in a well-kept condition. Replacement covers those activities taken when a worn-out element or portion thereof is replaced. Rehabilitation refers to a set of activities as necessary to bring a deteriorated project back to its original condition. Repair, replacement and rehabilitation (RR&R) actions are to conform to the project as-built plans and specifications unless other arrangements are made with the district commander. These activities are the responsibility of the Superintendent.

12-02. All repairs, replacements, and/or rehabilitations should be made as recommended in the USACE's *"Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project,"* and to the specifications for the original project construction.

12-03. The Superintendent should take into consideration the timing and urgency of the specific repairs. Depending upon the nature and severity of the repair, it may be advisable to proceed with the repairs prior the next flood season, or to proceed cautiously during a current flood season. Other methods or procedures may need to be deployed by the Superintendent and approved by the USACE if the repairs are required during an immediate flood season.

12-04. Damage to relief wells must be corrected promptly. Any condition that prohibits flow in or from relief wells could result in potentially unstable and hazardous conditions. Malfunctioning and damage to the relief wells can be caused by vandalism, breakage, or excessive deformation of the well screens due to ground movements, corrosion or erosion of the well screen.

a. Repair. The need for relief well repairs is described in EM 1110-2-1914 as follows:

"The analysis of well discharge records and accompanying piezometric data will often indicate whether the relief wells are functioning as intended. A decrease in well discharges with time for similar river stages with rising piezometric levels between wells is usually indicative of decreasing well efficiency. A quantitative measure of the loss in efficiency is only determined by carefully conducted pumping tests. Should the pumping tests indicate a reduction in specific capacity of more than 20 percent compared to that measured at installation, a detailed study should be made of the consequences of the reduction and what remedial measures should be employed. Generally, it may be possible to restore the wells to near their original efficiency by means of rehabilitation techniques."

b. Rehabilitation. The need for relief well rehabilitation is described in EM 1110-2-1914 (Chapter 12) as follows:

i. Mechanical Rehabilitation

Plugging of relief wells by silts, clays, or other particulate media entering the filter pack either from the formation or through the top of the well is usually difficult to determine except as indicated by periodic pumping tests. If significant reductions in specific yield are noted, rehabilitation of the well is in order. Mechanical redevelopment of the well similar to that used to develop a new well should be the first step. Over pumping or pumping the well at the highest rate attainable is generally advantageous. Surging and the use of horizontal jetting devices also may produce beneficial results.

ii. Chemical Treatment

Mechanical plugging of relief wells is corrected most often by chemical treatment with polyphosphates. These chemicals act as dispersing agents that cause silt and clay particles to repel one another. They also cause calcium, magnesium, and iron ions adhering to the particles to remain in a soluble state. The most widely used chemicals for this purpose are the glassy sodium phosphates which are inexpensive and readily available. The chemicals are usually applied in concentrations of 15 to 25 pounds per 100 gallons of water in combination with at least 50 ppm of chlorine (about one-half gal of 3 percent household bleach or chlorox in 100 gallons of water). Phosphate solutions are mixed in a barrel or tank adjacent to the well. The material is best dissolved in small amounts in a wire basket or perforated container in agitated or swirling water. If the material is dropped directly into the tank or well, it will sink to the bottom and form a large gelatinous mass that could remain undissolved for some time. One of the most effective means of introducing the phosphate and chlorine solution into the well is by means of a horizontal jetting device. The well should then be surged vigorously prior to pumping. Three or more repetitions of injecting, surging, and pumping over a 2 to 4-hour cycle will be much more effective than a single treatment with a longer detention time.

As clogging of well screens and filter materials is caused not only by the organic material produced by the bacteria but also by oxides and hydroxides of iron and manganese, better results are usually obtained by treating the well alternately with a chlorine compound to attack the organic material and a strong acid to dissolve the mineral deposits. Between each treatment the well is pumped to waste to ensure that chlorine and acid are not in the well at the same time. A recommended procedure using the two procedures is:

a. Inject a mixture of acid, inhibitor, and wetting agent. The addition of a chelating agent such as hydroxyacetic acid may

sometimes be beneficial. An inhibitor is needed only if the well screen is metal. The amount of acid should be typically one and a half to two times the volume of the well screen. If a chelating agent is not used, iron will precipitate out if the pH rises above 3. The precipitate can result in clogging; therefore the pH should be monitored throughout the acid treatment and not be allowed to rise above 3 regardless of whether a chelating agent is used.

b. Gently agitate the solution with a jetting tool at b-mm intervals for a period of 1 to 2 hours.

c. Pump out a volume of solution equal to the volume of the well.

d. Determine the pH of solution removed from the well. If the pH is more than 3, repeat steps (a) to (c).

e. Allow the acid to remain in the well for a minimum of 12 hours and then pump to waste.

f. Inject a mixture of chlorine and one or more chloric-stable surfactants (detergents and wetting agents, for example). The concentration of the chlorine should exceed 1,000 ppm.

g. Gently agitate the solution with a jetting tool at b-mm intervals every 2 hours for the first 8 hours and then at 8 hour intervals for at least 24 hours.

h. Pump out a volume of solution equal to the volume of the well.'

i. Determine chlorine concentration. If the concentration is less than 10 percent of the original concentration, repeat steps f to h.

j. Perform a pumping test on the well. If the specific capacity has improved by more than 5 percent, repeat the entire procedure until the specific capacity does not improve by 5 percent.

Table 12-1: Quantities of Various Chlorine Compounds Required to Provide as Much Available Chlorine as 1 lb. of Chlorine Gas

Chemical	*% Available Chlorine*	*Number of lb. Equivalent to 1 lb. Cl_2*
Chlorine Gas	*100*	*1.0*
Calcium Hypochlorite	*65*	*1-54*
Lithium Hypochlorite	*36*	*2.78*
Sodium Hypochlorite	*12.5*	*8.0*
Trichlorisocyanuric Acid[2]	*90*	*1.11*
Sodium dichloroisocyanurate[2]	*63*	*1.59*
Potassium dichloroisocyanurate[2]	*60*	*1.67*
Chlorine Dioxide	*4*	*25*
Chlorine Dioxide	*2*	*50.0*

Notes:
1. From Driscoll (1986).
2. Chlorine compounds that incorporate isocyanuric acid stabilize the chlorine against degradation from sunlight. Except for storage, the advantage offered by the addition of isocyanuric acid is less valuable in water wells.

iii. Specialized Treatment

The USACE Waterways Experiment Station personnel, funded under a repair evaluation maintenance and restoration (REMR) work unit, developed a field procedure (Kissane and Leach 1991) for cleaning water wells that provides initial kill of the active bacteria in the well, dissolves the biomass in the screen, in the gravel pack, and some distance into the aquifer, and provides some inhibition of future growth. The procedure was developed using a patented process known as the Aliord Rodgers Cullimore Concept (ARCC). The procedures in general include an initial well diagnosis performed with a prepackaged field microbiological test kit which is designed to give a qualitative indication of the types of bacterial and chemical agents at work in the wells, and a very general indication of the bacterial concentrations. The initial water chemistry is also measured prior to treatment. A treatment is then designed with the information from the tests, targeting the problematic agents with an appropriate set of chemicals. Redevelopment of the wells using the ARCC method is based on the use of blended chemicals and high temperature (BCHT) and is divided into three principle elements of treatment:

a. **Shock.** This phase is achieved by adding high temperature chlorinated water to the well and surrounding aquifer to shock kill or reduce the impact of deleterious algae and bacteria. The water is chlorinated to >700 ppm with gaseous chlorine to avoid binders found in powdered chlorine and is applied to the well as steam until the well temperature is brought above 120 degrees F for massive bacteria kill. The chlorine treatment remains in the well for a specified period of time mechanical surging is used and pumping follows for removal of the initial loosened biomass.

Disrupt. This phase is achieved by the addition of chemical agents, acids and surfactants, and steam to the well and surrounding aquifer while the well is pressurized. Mechanical surging to break up organic and mineral clogging in the system is also used. The mechanical surging and chemical set time are important during this phase to achieve dissolution of the remaining biomass.

Disperse. This phase of treatment consists of removal of the material that has been clogging the well and aquifer. Acceptance criteria for the well are checked and further cycles are considered or a final cold chlorination treatment is applied for inhibition of any remaining bacterial colonies.

c. Replacement

Relief wells that are no longer acceptable due to collapse, excessive sediment production, or other condition should be replaced

according to the plans and specs. New wells should be installed and operational before the old ones are abandoned.

SECTION 13 NOTIFICATION OF DISTRESS

13-01. Notification of distress should be reported in accordance with ER 1110-2-101, *"Reporting of Evidenced of Distress of Civil Works Structures."*

APPENDICES – DRAFT ONLY INCLUDES B, N and O

APPENDIX B

APPENDIX N

Unit 148 Levee Mile, River Mile, and Design Station Conversion Table		
River Mile	Wood Rodgers Design STA	Levee Mile
30.28	1132+61	0.00
30.5	1144+11	0.22
30.75	1153+69	0.40
31	1158+36	0.49
31.25	1172+32	0.75
31.5	1188+82	1.06
31.75	1199+46	1.27
32	1210+24	1.47
32.25	1214+63	1.55
32.5	1220+68	1.67
32.75	1233+36	1.91
33	1245+47	2.14
33.25	1259+34	2.40
33.5	1267+95	2.56
34.07	1279+96	2.79
34.5	1284+07	2.87
34.8	1299+91	3.17
35.25	1304+22	3.25
35.5	1306+47	3.29
35.78	1322+48	3.60
36.24	1345+61	4.03
36.35	1346+46	4.05
36.45	1347+83	4.08
37.29	1360+58	4.32
37.45	1369+74	4.49
37.68	1377+80	4.64
37.95	1386+62	4.81
38.27	1406+31	5.18
38.45	1416+64	5.38
38.71	1431+06	5.65
38.94	1443+68	5.89
39.23	1458+08	6.16
39.45	1470+01	6.39
40.19	1489+95	6.77
40.49	1495+90	6.88
40.7	1502+72	7.01
41.2	1506+01	7.07
41.55	1519+08	7.32
41.61	1523+41	7.40
42.01	1526+95	7.47
42.19	1529+12	7.51
42.47	1532+03	7.56
42.65	1537+66	7.67
43.01	1562+49	8.14

Unit 148 Levee Mile, River Mile, and Design Station Conversion Table		
River Mile	Wood Rodgers Design STA	Levee Mile
43.06	1564+60	8.18
43.12	1566+13	8.21
43.23	1571+05	8.30
43.28	1573+74	8.35
43.34	1576+28	8.40
43.46	1582+71	8.52
44.23	1593+11	8.72
44.5	1600+88	8.87
44.6326	1612+14	9.08
44.76	1632+51	9.47
45.03	1647+33	9.75
45.24	1656+15	9.92

APPENDIX O