West Point Treatment Plant Independent Evaluation of Mitigation Strategies

Prepared for:

King County Department of Natural Resources and Parks, Wastewater Treatment Division

Final Report
March 1, 2019

AECOM

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TABLES

ABBREVIATIONS

ACC	area control center
AMS	asset management system
BPCS	Basic Process Control System
CMMS	Computerized Maintenance Management System
Council	King County Council
County	King County
CSO	combined sewer overflow
DHS	U.S. Department of Homeland Security
DOE	Washington Department of Ecology
EAM	enterprise asset management
EB	Emergency Bypass
EBO	Emergency Bypass Outfall
EMO	Emergency Marine Outfall
EPA	U.S. Environmental Protection Agency
ERWG	Emergency Recovery Working Group
FEMA	Federal Emergency Management Agency
HAZOP	hazard and operability
HSEEP	Homeland Security Exercise and Evaluation Program
I&C	instrumentation and control
ICS	influent control structure
LSM	Life Safety Management
MC	Main Control
MG	million gallons
MOC	Management of Change
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
PE	primary effluent
PM	preventive maintenance
PSM	Process Safety Management
RSP	raw-sewage pump
SIS	safety instrumented system
SCADA	supervisory control and data acquisition
SOP	standard operating procedure
WO	Work Order
WPTP	West Point Treatment Plant
WTD	Wastewater Treatment Division

EXECUTIVE SUMMARY

King County Wastewater Treatment Division (WTD) engaged AECOM to conduct an independent evaluation of the progress made by WTD to address the recommendations and associated 98 potential mitigation strategies cited in the 2017 West Point Treatment Plant Independent Assessment (AECOM 2017). This report summarizes the results of this independent evaluation of the mitigation strategies, responses provided by WTD to address the recommendations, and the current implementation status of the technical strategies being used to avoid loss and damage to the West Point Treatment Plant (WPTP) and to address similar future flooding events.

This evaluation was based on interviews and communications with WTD staff and a review of documentation. Based on the information provided by WTD, review of the reports and follow-up meetings to further clarify and understand the status of activities, the AECOM technical team found that WTD has fully evaluated all of the 98 mitigation strategies. WTD has completed 52 of the 98 strategies and they are in the process of implementing 26 of the strategies. Based on further review and post-event actions, WTD had deemed that 20 of the strategies were not applicable or feasible, and AECOM agrees with this assessment.

The evaluation team also reviewed the progress made with respect to the four major recommendations presented in the 2017 Independent Assessment:

1. **Implement a Life Safety Management program.**

   The evaluators concluded that the LSM program has been initiated and that implementation of this recommendation is complete. WTD should continue with the future planned activities to further develop and document the Management of Change (MOC) program and other programs to facilitate the delivery of all of the LSM materials. No additional actions are recommended to support recommendation #1.

2. **Conduct comprehensive emergency response training.**

   This evaluation concluded that the WTD has made significant improvement to its operator training program, including the emergency response training program. WTD should continue with the future actions planned, which involve the continued progress towards a comprehensive emergency training and exercise program. Additional actions that could be taken to enhance the operator training program are provided in Section 4 for consideration.

3. **Conduct an integrated evaluation to address plant constraints and improve redundancy.**

   The strategies that the WTD has implemented or is planning to implement helps to address the lack of passive systems which would allow the plant to handle flows through the facility in the event of loss of automation, lack of power, or delayed decision-making. No additional actions are recommended to support recommendation #3.

4. **Optimize a capital improvement plan to maximize redundancy.**

   This evaluation found that WTD has implemented many of the short-term improvement strategies and is in the planning process to implement the longer-term improvement strategies. WTD should continue with the future planned activities to integrate the LSM program with the Asset Management Program which will help WPTP prioritize these capital improvements. They should also continue the alarm management review process. No additional actions are recommended to support recommendation #4.

1. PURPOSE, SCOPE AND APPROACH

1.1 Purpose

WTD engaged AECOM to conduct an independent evaluation of WTD's analysis of, and progress on, implementation responses to the 98 technical strategies cited in the 2017 WPTP Independent Assessment (AECOM 2017). The purpose of this follow-up study is to review WTD's responses, action plans, and progress of each strategy, which is provided in **Appendix A,** and provide WTD with an independent opinion on the implementation status. This report is intended to present an opinion based on communications with WTD staff and readily available information from applicable documentation, and it is not considered a comprehensive evaluation of WTD or of WPTP.

1.2 Scope and Approach

The analysis is based on interviews and communications with WTD staff from Project Planning and Delivery, and Operations & Maintenance groups. It is also based on a review of documentation provided by WTD about programs and projects related to WPTP improvements (**Appendix B**). The AECOM technical team provided an evaluation of the WTD's progress on implementation of the mitigation strategies based on the outcome of the interviews and the documentation that was provided. They also noted the future actions planned, and any additional actions that build on the strategy from the 2017 Independent Assessment. The AECOM technical team was composed primarily of the same team members that carried out the 2017 Independent Assessment.

This report summarizes the data that was reviewed, the assessment approach, findings and recommendations. The report is organized into the following sections:

- Section 1, "Purpose, Scope, and Approach"
- Section 2, "Background"
- Section 3, "Plant Upgrades and Improvements"
- Section 4, "2019 Independent Evaluation"
- Section 5, "Summary and Conclusions"

Section 2 provides a brief history of the February 2017 flooding event and AECOM's Independent Assessment, including WTD's follow-up to the 2017 Independent Assessment. **Section 3** summarizes the major upgrades and improvements that WTD has implemented since the flood event, while **Section 43** evaluates WTD's analysis of, and progress on, implementation responses to the 98 strategies cited in the 2017 WPTP Independent Assessment. **Section 5** summarizes the conclusions of this 2019 evaluation.

2. BACKGROUND

On February 9, 2017 during heavy rainfall in the Seattle area, West Point Treatment Plant (WPTP) was operating at peak hydraulic capacity, when a partial interruption of power supply occurred. The ensuing cascade of events caused several elements of the treatment plant to fail, culminating in flooding of WPTP. Flooding of the plant resulted in considerable damage to the plant's infrastructure, including its subterranean facilities and bypasses of untreated stormwater and wastewater into Puget Sound.

Recognizing the significant impacts of this event, the King County Council (Council) contracted with AECOM Technical Services to perform an investigation to independently assess the causes and consequences of failure, review corrective actions taken by the County Wastewater Treatment Division (WTD), and recommend next steps for developing preventive strategies, practices and infrastructure upgrades to avoid a recurrence of a similar incident.

The results of the Independent Assessment, which were delivered to Council on July 18, 2017, included the output of a HAZOP workshop and follow-on efforts resulting from discussions with plant operators. Technical teams investigated each key area of the plant that could lead to a failure of function. As with failure of any complex infrastructure of this magnitude, several contributing factors led to the eventual flooding of WPTP and several potential failure mechanisms were identified.

Based on these conclusions, the following four major recommendations were proposed to address the key findings and to reduce the likelihood of future issues at WPTP:

1. Implement a Life Safety Management program.
2. Conduct comprehensive emergency response training.
3. Conduct an integrated evaluation to address plant constraints and improve redundancy.
4. Optimize a capital improvement plan to maximize redundancy.

Several mitigation strategies were developed to address the potential failure mechanisms. The technical strategies were presented in the 2017 Independent Assessment in tables that identified potential failure mechanisms and mitigation strategies. These tables were organized by process areas of the plant: overall plant hydraulics, process and mechanical systems, electrical and system instrumentation, and the O&M processes and operations. **Table 1** lists the original table number and title from the report and the number of potential mitigation strategies that were identified for each plant process or operational area.

Following the July 2017 Independent Assessment, the Council adopted legislation on December 17, 2017 to help WTD take the necessary steps to ensure that WPTP is prepared to both prevent future floods and respond to potential emergency situations. King County Ordinance 18628 requires an Implementation Plan for the AECOM Recommendations that specifically addresses each of the 98 recommendations listed in the report (AECOM 2017). The mitigation strategies from the 2017 Independent Assessment, which became known as the 98 recommendations, are provided in **Appendix A**.

WTD has worked to evaluate each of the 98 mitigation strategies that were included in the 2017 Independent Assessment and has tracked and reported on their implementation progress to Council quarterly. During the Q3 2018 quarterly report (WTD 2018), WTD reported that they have completed 52 of the strategies, and that they are in the process of implementing 26 of the strategies (**Table 1**). 20 of the strategies were not incorporated because they were either in conflict with other strategies or they were found to be impractical based on the configuration and control of the collection system and plant hydraulics, or they were replaced with a more effective alternative solution. The 2017 Independent Assessment was limited in scope and provided potential mitigation strategies for WTD to

consider for evaluation based on a potential failure mechanism of a plant process or operational procedure. The potential mitigation strategies were not finalized recommendations, and upon further investigation, some of the potential mitigation strategies were not the most practicable alternative. An explanation is provided in **Appendix A** for any recommendation that will not be implemented and if WTD is planning to implement an alternative.

Table 1. Implementation Status of the Mitigation Strategies from the 2017 Independent Assessment[1]

Table Number[2]	Process Area	Number of Potential Mitigation Strategies	Adopted		Not Implemented[3]
			In Progress	Completed	
10	Plant Hydraulics	6	5	1	0
11	Influent Control Structure	8	3	4	1
12	Preliminary Treatment	2	0	1	1
13	Raw Sewage Pump Station	8	2	5	1
14	Preaeration and Sedimentation Tanks	7	2	1	4
15	Flow Diversion Structure	3	0	3	0
16	Effluent Pump Station	11	1	6	4
17	Electrical	9	2	5	2
19	Instrumentation and Control	12	6	1	5
21	Staffing	2	1	1	0
22	Operators	13	3	9	1
25	Training	5	0	5	0
26	Equipment and Systems Testing	9	1	7	1
27	Maintenance Procedures	3	0	3	0
	Totals	**98**	**26**	**52**	**20**

1 *As reported in the West Point Quarterly Report Q3 2018 (WTD 2018)*

2 *From the 2017 Independent Assessment (AECOM 2017)*

3 *Appendix A includes an explanation for each recommendation that was not implemented.*

3. PLANT UPGRADES AND IMPROVEMENTS

After the flood event, WTD recognized the need for change and has moved forward with a number of improvements and upgrades to protect facilities, strengthen operational practices and emphasize employee safety. WTD has replaced or rebuilt thousands of pieces of electrical and mechanical equipment and instruments and has completed several major capital upgrades. They have also implemented new safety and training policies that protect workers and equipment. **Table 2** summarizes the major plant upgrades and operational practice improvements that have occurred since the flood event. The upgrades and improvements that were implemented to address the major recommendations from the 2017 Independent Assessment are described in further detail below.

Table 2.Recently Completed or In-Progress WPTP Upgrades and Improvements

Device/System to Improve	Corrective Action Recommended	Corrective Action Taken	Status
Plant Operations Simulator	Develop complete model	Ovation user interface hydraulic model	Completed
Tunnel Access Protocols	Add administrative controls	Tunnel access during high flows now limited	Completed
RSP // Primary Sedimentation Float Interlock	Replace existing system	New float design and installation	Completed
EPS Power Supply	Add redundant power	Installed Automatic Transfer switch	Completed
EPS Valve Operations	Add redundant control	Installed redundant hydraulic system	Completed
ICS // Wet Well Gate Float Interlock	Replace existing system	New float design and installation	Completed
Operator Training	Expand and improve shift operator training	Trainings improved and new shift Supervisor of Training hired	Initiated and Ongoing
Life Safety Evaluation	Review control systems and equipment for LSM impacts	Flood protection hazard analysis completed. Next steps addressed through future capital project	Completed
Life Safety Implementation	Develop LSM Program	Apply LSM specific procedures to identified equipment with new LSM coordinator	Initiated and Ongoing
SCADA Alarm Management	Prioritize critical alarms	Priority alarm visibility improved	Initiated and Ongoing
Hydraulic Capacity of RSP's	Increase RSP capacity to 150 MGD each (N+1)	Conducted feasibility study for increasing RSP capacity	Completed
Passive Emergency Bypass Weir	Add automatic Emergency Bypass	Conducted feasibility study for Passive Weir	Completed
Emergency Bypass Procedures	Develop clear protocols for when to open the Emergency Bypass gates	Documented scenarios and update SOPs	Completed
Emergency Bypass gate control	Add ability to remotely operate Emergency Bypass gate from Main Control	Installed manual push button in Main Control	Completed

(RSP= Raw Sewage Pump, EPS = Effluent Pump Station, ICS = Influent Control Structure, SCADA = Supervisory control and data acquisition, LSM= Life Safety Management, SOP= Standard Operating Procedure, MGD = Million Gallons per Day)

3.1 Life Safety Management Program

One of the major recommendations that came out of the 2017 Independent Assessment was that WTD should develop and implement an approach for critical hydraulically critical equipment similar to the Process Safety Management (PSM) program. At WPTP, the PSM Program covers the methane and propane gas systems and is a formal process that enhances communication and structures the decision-making process to increase the focus on safety for workers and the public. A Life Safety Management (LSM) program was developed by leveraging the most effective elements of PSM into a new system to cover critical hydraulic equipment. Under LSM, operations and maintenance procedures are more strictly applied, and all WTD staff work together to achieve the best possible

outcomes. This approach improves communications across all of the different WTD working groups regarding plant risks.

WTD has hired a Life Safety Coordinator to create and implement the LSM program at WPTP. The LSM coordinator has initiated the development of aspects of the Management of Change (MOC) program. WTD is also currently advertising for a permanent WTD-wide LSM coordinator.

3.1.1 Life Safety Evaluation

The LSM program started with a thorough, systematic evaluation of WPTP systems in terms of function, performance, and safety. A plant-wide Flood Protection Hazard Analysis was conducted in October and November 2017 to support the overall life safety effort at the plant.

During the 2017 Hazard Analysis, two major events were identified as having the potential to cause of flooding at WPTP; 1) wet well overflow and, 2) failure of a major piece of equipment or pipe. For each identified risk, the consequence and likelihood of the event occurring was identified. The outcome of this Hazard Analysis was a set of recommendations that were arranged into four groups by their implementation type: 1) plant improvements, 2) procedural improvements, 3) basic process control improvements, and 4) safety instrumented system (SIS) improvements.

The hazard analysis helped define what assets should be categorized as LSM designated equipment. The LSM coordinator will use this information to apply LSM specific procedures to any work or procedural changes that touch that equipment. WTD is working to fund a capital program to evaluate and implement those LSM related recommendations that WTD determined will benefit the plant and decrease the risks and consequences of future flood events.

3.1.2 West Point Flood Risk Reduction System

Operators and the Basic Process Control System (BPCS) normally manage the flow through the plant. However, if circumstances cause specific wet wells to rise to overflow levels, WTD has mitigated that risk with redundant controls (flood risk reduction system) that allow operators to immediately and easily place WPTP in a safe condition. When needed, the plant is placed in a safe state and flows are diverted by opening the bypass gates, closing the influent gates, and stopping the raw sewage pumps. An audible and visual alarm will activate in Main Control (MC).

The flood risk reduction system is being added on top of and independent from the existing control system, creating a third, parallel layer of protection that will be initiated when specific wastewater tanks are at extreme levels and about to overflow or in the case of a large pipe rupture. Tanks will be equipped with a set of flood level detection switches which include three tethered ball floats set at the same height and a safety off-delay relay that is tripped if two of the three float switches indicate the wastewater has reached the flood level. In the event that a pipe or tank rupture occurs, level sensors in the underground occupied spaces will trigger emergency alarms.

If necessary, an operator can manually activate the flood risk reduction system via the manual emergency button in main control. An oversized, illuminated red, latching, mushroom pushbutton with twist release has been mounted on the north wall in MC. This is for operations personnel to activate the flood risk reduction system if they determine there is a need to bypass flow away from the plant.

The flood risk reduction system has been designed and will be implemented in 2019. When complete, it will be managed as part of the WPTP LSM program, and it will be redundant to the existing control system.

3.2 Emergency Bypass Protocols

The plant was designed to bypass to protect life and the facility. In the event that flows exceed the ability of the plant to receive and treat effluent, or should a major failure occur at the plant, the design includes an emergency bypass gate that can convey the entire flow from the plant to the Emergency

Bypass Outfall (EBO). While discharge of untreated wastewater is a reportable event, it is understood that this protects the plant so that it can continue to fulfill its mission once the short-term emergency or extreme-flow event passes. The results from the 2017 Independent Assessment showed that at the time of the event, there was a lack of clarity among crew members in identifying the threshold for initiating and implementing emergency bypass procedures.

The WTD has updated the standard operating procedures (SOPs), and they now provide clear protocols for when and how to open the Emergency Bypass (EB) gates. Additionally, the WTD Wastewater Plant Operations & Maintenance Manager has written a technical memorandum that describes the West Point Emergency Outfall gate operating procedure (Waddle 2017) (**Appendix C**). This memorandum formalized guidelines for when the EB gate must be opened by a Shift Supervisor at WPTP. The memo provides four example scenarios where manual use of the gates may be needed; it makes it clear that the EB gate must sometimes be opened in order to prevent any harm to staff or to the plant itself. Combined with updates to the EB gate SOPs, this memorandum has changed the culture of the plant. The operators now have a clearer understanding of how to respond in an emergency event.

3.3 Alarm Management System

At the time of the event, the recently commissioned Ovation plant control system conveyed a rapid series of alarms to MC that were not yet fully prioritized. The shift supervisor was faced with more than 2,100 alarms in less than 1 hour, and it was not clear which alarms were critical and which were of lesser significance. The lack of prioritization in the system configuration made it difficult for the shift supervisor to make informed decisions efficiently.

WTD has expended a significant amount of time and money in developing and implementing an Alarm Management System for West Point. An alarm management workshop was held to properly prioritize alarms and remove or condition alarms. The initial phase of this work (Phase I) included reviewing 33,000 alarm points, determining priorities and conditioning of the alarms and removing unnecessary/redundant alarms. The Ovation alarms are now better organized and will improve operational efficiency during emergencies and follow Industry Standards (ISA 18.2). WTD staff will continue to remove nuisance alarms and further fine-tune alarms during weekly alarm review meetings (Phase 2).

3.4 FEMA 406 Public Assistance Mitigation

Disaster-damaged facilities have additional funding opportunities available through the Federal Emergency Management Agency (FEMA). FEMA 406 funding provides discretionary authority to fund hazard mitigation measures in conjunction with the repair of the disaster-damaged facilities for cost-effective measures that will improve on the pre-disaster design and will prevent future similar damage to your facility. WTD is planning to request funding from FEMA for several projects that will further reduce flood risk at WPTP. However, funding is not guaranteed, and projects that do not qualify for a FEMA grant will compete with other projects for capital funds.

3.5 Additional Planned Projects

Along with the projects that are seeking funding through FEMA's grant program, WTD is planning the following activities that will further address flood risks at WPTP:

- Development of emergency Work Order (WO) construction and consultant contracts templates to be quickly deployed in the event of an emergency.
- Development and implementation of an Emergency Recovery Working Group (ERWG) to further enhance the Division's ability to respond to emergencies. The first effort by ERWG will be to create an emergency preparedness plan for Project Planning and Delivery within WTD that dovetails with Operation's Emergency Response Plan.

4. 2019 INDEPENDENT EVALUATION

4.1 Evaluation Methodology

The AECOM technical team was composed primarily of the same team members that carried out the 2017 Independent Assessment. A technical expert was assigned to each of the following technical areas: WPTP processes, system controls, mechanical, electrical, staffing and operations, and training. Each technical expert led interviews with WTD staff from Project Planning Delivery and Operations & Maintenance. They asked questions to the applicable WTD personnel to verify and assess the progress that WTD has made to date on each of the 98 strategies cited in the 2017 WPTP Independent Assessment (AECOM 2017). WTD worked to ensure that the technical team had access to the proper personnel or documentation that could resolve any questions that the technical team had about any equipment or programs. The technical lead then provided an evaluation of the WTD's progress on implementation of the mitigation strategies based on the outcome of the interviews and the documentation that was provided. If a strategy could be categorized in multiple technical areas, then each technical expert reviewed it independently, followed by additional evaluation as a team.

The evaluation assessed the status of each mitigation strategy. The following options were used to summarize the status of each mitigation strategy:

- **Complete:** Action has been taken to complete a strategy or initiate an operational procedure or program. It is important to note that some of the strategies, particularly those that recommend large, programmatic or procedural changes, will never be 100% complete. For these strategies to be successful, they require constant and ongoing support. The evaluation made note of the steps that have been taken to initiate a strategy and noted if the implementation was ongoing as part of a larger continuous improvement effort.
- **In Progress:** Action identified in strategy is underway and is on-track to be completed as intended.
- **Under Evaluation:** Action identified in strategy is still being considered.
- **Implementing Alternative:** WTD did not use the exact strategy but they have implemented or will implement another action that meets the intent of the mitigation strategy and addresses the potential failure mechanism.
- **Not Incorporated:** The potential mitigation strategy that we recommended is not feasible at WPTP or it will not address the potential failure mechanism.

The evaluation also noted if there were future actions planned by the WTD and if any additional actions were recommended by the technical team.

4.2 Evaluation Summary

This 2019 independent evaluation found that the WTD has fully evaluated all the strategies cited in the 2017 WPTP Independent Assessment, and that they have or are planning to implement all the strategies that are applicable or feasible. The technical team agreed with WTD's assessment of the strategies that were deemed not applicable or feasible. The technical team was also satisfied that the alternatives still meet the intent of the original strategy and that the alternatives will address the potential failure mechanism.

Although WTD is still in the process of implementing all of the planned plant upgrades and implementing new operational processes that were recommended following the event, they have made significant progress to increase the safety and operations of WPTP. It is understood that some of the strategies, particularly those that recommend large programmatic changes, will never be 100% complete. These strategies are part of continuous improvement efforts that will be embedded into

existing and ongoing business and operational processes. In order for these programs to be successful, they require constant and ongoing management and financial support. For the purposes of this 2019 evaluation, initiated and ongoing satisfies the intent of the original recommendation.

This 2019 evaluation found that WTD has made significant progress on the implementation of the 98 potential mitigation strategies that were designed to help meet the overall goals of the following recommendations:

1. Implement a Life Safety Management program.
2. Conduct comprehensive emergency response training.
3. Conduct an integrated evaluation to address plant constraints and improve redundancy.
4. Optimize a capital improvement plan to maximize redundancy.

The following sections list the strategies that support each recommendation and provide a summary of the implementation status, and the future actions planned by the WTD. It also notes additional actions that the technical team is recommending to further improve upon the original mitigation strategy. These suggestions are to further improve upon the work that WTD has already begun and are not meant to imply that that any of the current responses are inadequate.

4.2.1 Recommendation #1: Implement a Life Safety Management Program

The 2017 Independent Assessment found that there was no system in place to make sure WPTP hydraulic processes and operational procedures were functioning as a whole or that issues with systems or equipment were communicated to all groups responsible. Due to the size of WPTP, its complexity, limited redundancy, and environmental conditions, the operational procedures needed to be elevated. The recommendation was that the WTD should develop and implement a LSM program.

The potential mitigation strategies that support the LSM program recommendation are listed in **Table 3**. The table includes the potential failure mechanisms and effects identified in the 2017 Independent Assessment, as well as the implementation status of the strategies, future planned actions, and any additional recommendations from this current evaluation.

4.2.1.1 Evaluation

The WTD have hired a Life Safety Coordinator and a plant-wide Flood Protection Hazard Analysis was conducted in October and November 2017 to support the initial Life Safety Evaluation. That Hazard Analysis, which will be continuously refined, provides a framework of recommendations that the West Point employees will implement and maintain. Ongoing work should evaluate the risk after the recommended actions are implemented, and should rank, prioritize, and schedule the recommended actions.

Future planned activities include further development and documentation of the Management of Change (MOC) program including the creation of a comprehensive decision-making tree, and the process for emergency and temporary changes. A pilot Paper Program that lays out the work flow for a low-, medium- and high-risk changes is also in the works, along with a SharePoint Pilot Program that is being developed in order to facilitate the delivery of all of the LSM materials. LSM documentation will provide clear operator and plant safety objectives.

The evaluators concluded that the LSM program has been initiated and that implementation of this recommendation is complete. Work will continue to be ongoing. No additional actions are recommended to support recommendation #1.

Table 3. Evaluation of the Mitigation Strategies that Support Recommendation #1

Potential Failure Mechanism	Effects	Potential Mitigation Strategy	Strategy Number	Evaluation Status Comment	Future Planned Action	Additional Actions Recommended
No system in place to make sure hydraulically critical plant processes and operational procedures are functioning as a whole or that issues with systems or equipment are communicated to all groups responsible	Risk to life safety and plant failure	Implement a Life Safety Management program.	75,91,96, 97,98	Life Safety Coordinator hired and an initial Life Safety Evaluation was completed. LSM program initiated and ongoing.	Continue LSM program progress, including development and document of MOC program.	None.

4.2.2 Recommendation #2: Conduct Comprehensive Emergency Response Training

Training can help employees maintain competency for completing their specific tasks during an emergency, as the roles they assume in an emergency could differ from their normal duties. The 2017 Independent Assessment concluded that additional training and exercises that focused on using the lessons learned from the February 9, 2017 incident were needed. A comprehensive program of emergency training and emergency exercises promotes sharing of ideas, leads to documentation of important decisions, helps increase staff comfort levels regarding unusual emergency-only activities through discussion and practice, and ensures that proper protocols are followed.

In concert with the additional recommended emergency training, a progressive exercise program that provides opportunities to validate plans and procedures and identify and correct potential weaknesses and deficiencies was also recommended. Exercises may include smaller scale drills and table top exercises.

The potential mitigation strategies that support the need for emergency response training recommendations are listed in **Table 4**. The table includes the potential failure mechanisms and their effects that were identified in the Independent Assessment, as well as the implementation status of the strategies, future planned actions, and any additional recommendations from the evaluation.

4.2.2.1 Evaluation

The WTD has dedicated resources to initiate an operator training improvement effort that includes creating new, and modifying existing, standard operating procedures (SOPs) as well as improving training modules and implementing an operator training simulator. Operations staff now have 1-on-1 on-shift training, there is more formal communication between crews, and access to tunnels during high flow has been limited. WTD has also worked to fully staff each Operations crew at WPTP to allow staff time for these trainings.

Operators are also being trained using desk-top exercises and scenario-based discussions to train on emergency response procedures. In the near future, these exercises will be incorporated into the simulator training program.

The evaluators concluded that WTD has made significant improvement to its operator training program, including the emergency response training program. The future actions planned involve the continued progress towards a comprehensive emergency training and exercise program.

The technical team recommends consideration of the following actions to enhance the operator training program:

- Adopting the use of Incident Command System common terminology and concepts in training programs and exercises.
- Adding a pre-exercise planning process to facilitate scenario planning. For example, focused exercises can help further define and clarify the bypass criteria/threshold SOP, and interactive and informal practice may help staff feel more comfortable with the decision-making process.
- Utilizing after-action reviews to evaluate a training exercise. This evaluation will include a summary of the lessons learned, and an improvement plan. Additional training, preparedness, mitigation, plans/procedures, and other improvements should be identified from the weaknesses identified during the exercises and become part of the after-action activities.

Table 4. Evaluation of the Mitigation Strategies that Support Recommendation #2

Potential Failure Mechanism	Effects	Potential Mitigation Strategy	Strategy Number	Evaluation Status Comment	Future Planned Action	Additional Actions Recommended
SOP does not include all of the recommended restart steps if there is a power outage failure at EPS.	Operators might spend time on a process that will not work.	Update and practice SOP for EPS restart after ground fault.	54, 81, 95	EPS restart SOP has been updated.	Continue to practice SOPs to be prepared in case of emergency.	None
Lack of consistent training for operators.	Inconsistent levels of system knowledge and a lack of familiarity with the system as a whole.	Review operator training program.	68, 84, 85	The operator training program has been significantly improved and has dedicated resources. Implementation complete with ongoing improvements planned.	Continue to implement operator training program improvements.	Consider adding a pre-exercise planning process Consider utilizing after-action reviews to evaluate the exercises
No SOP exists for emergency bypass.	Operators were not comfortable making the emergency bypass decision.	Create an Emergency Bypass SOP.	69	An Emergency Bypass SOP has been created and management has provided clear directions for when an emergency bypass should be utilized.	Use simulator to practice different bypass scenarios.	None
Operators are not comfortable making decisions during the event.	Flooding/life-safety issues occurred.	Provide hands-on Emergency Response Plan training.	73, 86	Emergency Response Plan training has been increased from once to twice per year.	Continue to implement operator training program improvements.	Consider adding a pre-exercise planning process Consider utilizing after-action reviews to evaluate the exercises Consider adopting the use of Incident Command System common terminology and concepts in training programs and exercises.
Main Control was not aware of flooding in the plant.	Flooding/life-safety issues occurred.	Provide Emergency Communications training.	80	Emergency Communications training has been incorporated into the WPTP Emergency Response Plan.	None	Practice Emergency Communication protocols regularly.
No designated emergency evacuation path.	Flooding/life-safety issues occurred.	Create a designated emergency evacuation path.	82	A designated emergency evacuation path has been created.	None	Practice walking emergency evacuation path regularly.

Potential Failure Mechanism	Effects	Potential Mitigation Strategy	Strategy Number	Evaluation Status Comment	Future Planned Action	Additional Actions Recommended
Failure of one RSP when influent flow rate is greater than 330 mgd	Water level will rise in the RSP wet well and at the ICS.	Run the hydraulic simulation model so operators know narrow time margins and potential consequences. Provide additional staff training on operating RSP.	21, 74	The hydraulic model is used regularly as a training tool for operators. Training on RSP has been increased.	Continue to train with hydraulic model and on RSP SOPs.	Increase the number and types of scenarios that are simulated.
No high-flow SOP for tunnel entry	Life-safety issue	Develop SOP for tunnel entry.	83	High-flow SOP for tunnel entry has been created and access to tunnels during high flow is now limited.	Evaluate potential costs and benefits of installing signal lights to communicate when tunnel entrance is restricted.	None
Annual testing done by removing covers and activating mercury switches manually without physically moving floats	Lack of testing of hydraulic protection equipment under actual conditions	Revise SOP for annual plant hydraulic safety.	90	Annual plant hydraulic safety SOP created and system is manually tested.	None	None

4.2.3 Recommendation #3: Conduct an Integrated Evaluation to Address Plant Constraints and Improve Redundancy

The incident of February 9, 2017, showed that failure in one area of the plant during high flows can quickly lead to a cascade of events at other locations in the plant. Lack of redundancy combined with the complexity of the system gives plant operators very little time to react during peak-flow events. The third recommendation from the 2017 Independent Assessment was to address the lack of passive systems which would allow the plant to handle flows through the facility in the event of loss of automation, lack of power, or delayed decision-making. The 2017 Independent Assessment also recommended that WTD's plan to address WPTP's firm-capacity limitations should incorporate upstream features in the collection system as well and lay the groundwork for developing a protocol for upstream combined sewer overflows (CSOs) and downstream treatment plant operations during high-flow events. And because plant operators have very little time to react during peak-flow events, an additional recommendation was to increase the clarity among crew members in identifying the threshold for initiating and implementing emergency bypass procedures.

The potential mitigation strategies that support the recommendation to address plant constraints and improve redundancy are listed in **Table 5**. The table includes the potential failure mechanisms and their effects that were identified in the Independent Assessment, as well as the implementation status of the strategies, future planned actions, and any additional recommendations from the evaluation.

4.2.3.1 Evaluation

WTD addressed one of the most critical potential points of failure at WPTP, the emergency bypass gate, with the Overflow Passive Bypass Weir Feasibility Study (WTD 2018). The study identifies and evaluates the potential to construct a passive bypass weir to safeguard WPTP against future flood events. The study concluded that it is feasible to convert and modify the existing Influent Control Structure (ICS) and surge channel into a new ICS that includes passive overflow. This will help reduce the potential of WPTP sewage overflow at the ICS.

WTD is already engaging in a variety of projects to optimize and improve the upstream collection system. Future actions will continue evaluation of additional strategies to improve control in the collection system, as this is already part of their planning process.

And lastly, with the updates to the EB gate SOPs and the technical memorandum (Waddle 2017), WTD management has provided clear directions for when an emergency bypass should be utilized.

In addition to implementing the strategies from the 2017 Independent Assessment, WTD has mitigated the flood risk if circumstances cause specific wet wells to rise to overflow levels, with the design of the flood risk reduction system. WTD is also determining where and how they can improve liquid detection and other alarms to better communicate to staff when an issue has, or is likely, to occur.

The strategies that WTD has implemented or that they are planning to implement helps to address the lack of existing passive systems at the plant. No additional actions are recommended to support recommendation #3.

Table 5. Evaluation of the Mitigation Strategies that Support Recommendation #3

Potential Failure Mechanism	Effects	Potential Mitigation Strategy	Strategy Number	Evaluation Status Comment	Future Planned Action	Additional Actions Recommended
WPTP has limited storage capacity and receives instantaneous flows exceeding its capacity.	Limited time to respond to emergency situations; high strain on equipment; potential to flood the plant.	Evaluate ways to improve control strategies and flow management within the collection system upstream of the plant.	1, 2, 3, 4, 5, 6	Passive Weir evaluation project has been completed and a project was approved as part of WTD's Six-Year Capital Improvement plan. Additional strategies to improve control in the collection system are under evaluation.	Continue existing planning process that evaluates additional strategies to improve control in the collection system	None
EB or EMO gate fails to open at ICS or FDS.	Flooding of plant if influent gates are open; also backup into Fort Lawton tunnels and North Interceptor.	Evaluate adding a passive bypass weir.	7, 32	Passive Weir evaluation has been completed and a project was approved as part of WTD's Six-Year Capital Improvement plan.	Pursue Ecology's approval of project prior to starting design and construction of a passive weir.	None
Flow surge in preliminary treatment area	Flooding of bar screen area	Raise the channel height at the bar screen area.	16	Implementing the passive weir project as an alternative.	None	None
Controls of the EB or EMO gate are overridden to keep the gate manually closed.	Life-safety risk	Avoid overriding controls of the EB gate to keep the gate manually closed.	8, 33	Standard operating procedures have been revised to ensure controls on the Emergency Bypass gate cannot be overridden except during maintenance.	None	None
Failure of one RSP when influent flow rate is greater than 330 mgd. Level switch in primary tanks interlock fails.	Water level will rise in the RSP wet well and ICS.	Evaluate incorporating automatic controls through a SCADA.	20, 27	The control system will be modified to reduce plant flow when levels are higher than normally allowed.	None	None
Effluent weir gate failure.	Effluent weir gate fails to open or close, which could lead to flooding/life-safety issues.	Evaluate feasibility of a passive bypass in preaeration and sedimentation tanks.	28, 29, 30	Implementing the passive weir project as an alternative. Gate inspections have increased, additional back-up power has been installed, and improvements to the control system have been initiated.	None	None

Potential Failure Mechanism	Effects	Potential Mitigation Strategy	Strategy Number	Evaluation Status Comment	Future Planned Action	Additional Actions Recommended
Operators were too focused on preventing an emergency bypass from occurring.	Operators were not comfortable making the emergency bypass decision.	Change the "no bypass" philosophy.	70,71	An Emergency Bypass SOP has been created and management has provided clear directions for when an emergency bypass should be utilized.	None	None
No routine testing of the PE gate interlock indicator in ACC-1	Failure of PE gate interlock indicator in ACC-1 to work during an event	Implement routine testing of the PE gate interlock indicator in ACC-1.	93	Routine testing of the PE gate interlock indicator in ACC-1 has been implemented.	None	None

4.2.4 Recommendation #4: Optimize a Capital Improvement Plan to Maximize Redundancy

WPTP has been upgraded several times over the years, but not all upgrades improved the plant's firm capacity or operational efficiency during emergencies. To maximize the capacity of WPTP within the existing footprint and to increase system reliability, the 2017 Independent Assessment recommended that WTD should implement a strategic plan that considers short-term and longer-term improvements. The longer-term planning processes should consider capital improvements that have immediate and significant impacts on plant capacity.

Post-2017 event analysis of maintenance records and SOPs that were in use at WPTP also showed the need for consistent application of asset management and Maintenance Best Practices standards.

The potential mitigation strategies that support the recommendation to consider short-term and longer-term improvements that maximize redundancy are listed in **Table 6**. The table includes the potential failure mechanisms and their effects that were identified in the Independent Assessment, as well as the implementation status of the strategies, future planned actions, and any additional recommendations from the evaluation.

4.2.4.1 Evaluation

WTD has made significant amount of capital improvements to WPTP since the event. Major upgrades include the addition of new float switches, redundant power feeds with automatic transfer switches, a new backup hydraulic power unit, an alarm management system, and the addition of a hard-wired emergency stop push button to open the emergency bypass gates from main control.

A study to evaluate viable alternatives to increase the firm capacity at the raw sewage pumps has been completed (WTD 2018). WTD has evaluated alternatives and has identified a viable alternative that will be implemented by a capital project that started in 2019.

Some of the capital improvement costs for improving redundancy, such as replacing the existing raw sewage pumps in order to increase the firm capacity, will be significant and they will take a significant amount of time to complete. Integrating the new LSM program with the asset management program will help WPTP prioritize capital improvements.

The existing Computerized Maintenance Management System (CMMS), Main saver, notes if a piece of equipment is designated as part of the LSM program, however it does not easily track these items. Future planned actions include the procurement of a new asset management (ASM) or enterprise asset management (EAM) system that will better support process and procedural improvements recommended by WTD's Life Safety Coordinator. Continued progress on purchasing and implementing a new asset management system should be prioritized.

The evaluators found that WTD has implemented many of the short-term improvement strategies and is in the planning process to implement the longer-term improvement strategies. No additional actions are recommended to support recommendation #4.

Table 6. Evaluation of the Mitigation Strategies that Support Recommendation #4

Potential Failure Mechanism	Effects	Potential Mitigation Strategy	Strategy Number	Evaluation Status Comment	Future Planned Action	Additional Actions Recommended
The emergency bypass gates cannot be remotely opened/closed from the Main Control room.	Unintentional bypass; Flooding of downstream processes; Delay in responding to emergencies; flooding/life-safety issues.	Add ability to remotely operate emergency bypass gates from Main Control.	9, 10, 11, 12, 65	A manual push button has been installed in Main Control to allow remote, emergency opening of the Emergency Bypass and Emergency Marine Outfall gates. Gates will not be allowed to close remotely. Operations staff is required to physically inspect equipment before gates are closed and equipment is restarted	None	None
RSPs and RSPs' influent gates cannot be remotely started/stopped or remotely opened/closed from the Main Control room.	Operations must send operators to locally start/stop the pumps or to open/close the gates, taking time and potentially placing operators in harm's way.	Add remote start/stop pump controls to the Main Control room through the Ovation system. Add a hard-wired emergency stop push button not controlled through Ovation.	60, 61, 62	A manual push button has been installed in Main Control to allow remote, emergency stop of all four raw sewage pumps. The existing engines cannot be restarted remotely.	Remote start will be considered as part of the Raw Sewage Pump Improvement project.	None
RSP engine/support system or piping system failure.	A 110 mgd reduction in pump station flow capacity; potential for flooding/equipment damage.	Evaluate options to provide 440 mgd firm pumping capacity at RSP. Evaluate current condition and determine expected life span. Provide backup systems to increase redundancy.	17, 23	A Raw Sewage Pump Improvement project was approved as part of WTD's Six-Year Capital Improvement Plan. It includes options to increase the capacity and add redundancy to the raw sewage pumps.	Implement capital plan to design and install new RSPs. Continue to evaluate current conditions with regular asset management practices.	None
Level switches fail to record high level in RSP, preaeration and sedimentation wet wells.	Flooding/life-safety issues.	Modify control strategy to include secondary instruments.	24, 26	Redundancy of secondary instrumentation has been reviewed and a replacement plan has been developed.	None	None
Level switches stick inside stilling well.	Flooding of plant; frequent tripping/idle mode of RSPs	Replace level switches with modern tethered switches that do not require a stilling well and are less likely to fail.	25	Tethered switches were installed during the restoration work immediately following the flooding event.	None	None

Potential Failure Mechanism	Effects	Potential Mitigation Strategy	Strategy Number	Evaluation Status Comment	Future Planned Action	Additional Actions Recommended
Failure of control valve/hydraulic operator system	If control valve closes and will not open, the pump will try to start, but with no flow to the system, it will shake and be shut off by the vibration monitor. If the control valve stays open, it will not operate as a check valve to prevent reverse flow.	Provide a spare hydraulic unit that can operate with any pump control valve.	35	One spare hydraulic power unit was added to one series of effluent pump station pumps. A capital project installed a hydraulic power unit on the other series.	None	None
		Provide redundant electrical power supply to all hydraulic power units.	36	Automatic transfer switches were installed.	None	None
		Add pressure relief valves at pump discharge lines.	37	As an alternative, West Point installed additional hydraulic power units to each Effluent Pump Station pump series.	None	None
Failure of EPS pump vibration monitor, pump support system.	Pump will stop; Damage to pumps will occur; eventual EBO discharge may result.	Routinely examine data from vibration monitors to determine trends to help forecast pump maintenance and repairs and update vibration monitors.	39, 40	A vendor for new vibration monitors has been procured and staff training has been initiated.	Continue staff training to help predict equipment failures.	None
		Evaluate the current condition of the EPS and determine its expected life span. Provide good maintenance, closely monitor systems, and stock critical spare parts.	41, 43	WTD's current asset management practices already require maintenance tracking and system monitoring.	Replace existing CMMS with a system that will support LSM processes and procedures.	None
Loss of power to EPS discharge valves hydraulic power unit	All EPS valves close, shutting down all EPS pumps, and eventual EBO discharge may result.	Provide additional permanently connected hydraulic power unit on the B side. Power EPS discharge valve controls from individual variable-frequency drives.	42, 48, 49	WTD improved reliability at the Effluent Pump Station by installing permanent hydraulic power units for each of the two sets of pumps, valves and variable frequency drives.	None	None

Potential Failure Mechanism	Effects	Potential Mitigation Strategy	Strategy Number	Evaluation Status Comment	Future Planned Action	Additional Actions Recommended
Lightning strikes and power line switching	Surge of electricity to critical equipment at the plant.	Add surge suppressors.	51	Medium-voltage transient surge suppressors have been installed on both sides of the main 15 kV switchgear.	New substations are requested as part of FEMA funded support. Medium-voltage TVSS equipment for new substations will be evaluated.	None
Wet well level float switches (high-high level) did not activate interlock or trigger a SCADA alarm.	Wet wells overflow, flooding the plant.	Remove the requirement to use both the High and high-high switches to activate the interlock.	58, 63	Implementation of LSM has been initiated and will evaluate existing control signals and alarms.	Continue LSM evaluations.	None
		Add an Ovation-level high-high signal to the hardwired interlock.	59, 64			
The Ovation system receives a large number of incoming alarms as an emergency develops.	The Main Control operator may be distracted or unable to process large amounts of information and make mission-critical decisions.	Conduct an alarm management review workshop to properly prioritize alarms and remove or condition alarms.	66,78,94	An alarm management review workshop was held and Phase 1 of an alarm management improvement process is currently underway.	A larger WTD-wide effort (Phase 2) will also be implemented.	None

5. SUMMARY AND CONCLUSIONS

Based on the information provided by WTD, review of the reports and follow-up meetings to further clarify and understand the status of activities, the AECOM technical team found that WTD has fully evaluated all of the 98 mitigation strategies. WTD has completed 52 of the 98 strategies and they are in the process of implementing 26 of the strategies. Based on further review and post-event actions, WTD had deemed that 20 of the strategies were not applicable or feasible, and AECOM agrees with this assessment.

This 2019 evaluation found that WTD has made significant progress on implementation of the 98 mitigation strategies that were designed to help meet the overall goals of the following four recommendations from the 2017 Independent Assessment:

1. **Implement a Life Safety Management program.**

   The evaluators concluded that the LSM program has been initiated and that implementation of this recommendation is complete. WTD should continue with the future planned activities to further develop and document the management of change (MOC) program and other programs to facilitate the delivery of all of the LSM materials. No additional actions are recommended to support recommendation #1.

2. **Conduct comprehensive emergency response training.**

   This evaluation concluded that the WTD has made significant improvement to its operator training program, including the emergency response training program. WTD should continue with the future actions planned, which involve the continued progress towards a comprehensive emergency training and exercise program. Additional actions that could be taken to enhance the operator training program are provided in Section 4 for consideration.

3. **Conduct an integrated evaluation to address plant constraints and improve redundancy.**

   The strategies that the WTD has implemented or is planning to implement helps to address the lack of passive systems which would allow the plant to handle flows through the facility in the event of loss of automation, lack of power, or delayed decision-making. No additional actions are recommended to support recommendation #3.

4. **Optimize a capital improvement plan to maximize redundancy.**

   This evaluation found that WTD has implemented many of the short-term improvement strategies and is in the planning process to implement the longer-term improvement strategies. WTD should continue with the future planned activities to integrate the LSM program with the Asset Management Program which will help WPTP prioritize these capital improvements. They should also continue the alarm management review process. No additional actions are recommended to support recommendation #4.

Although WTD is still in the process of implementing all of the planned plant upgrades and implementing new operational processes that were recommended following the event, they have made significant progress to increase the safety and operations of WPTP. It is understood that some of the strategies, particularly those that recommend large programmatic changes, will never be 100% complete. These strategies are part of continuous improvement efforts that will be embedded into existing and ongoing business and operational processes. In order for these programs to be successful, they require constant and ongoing management and financial support.

5.1 Statement of Limitations

AECOM represents that services are performed within the limits of, and in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation, expressed or implied, and no warranty or guarantee are included or intended.

Data used in the preparation of this report are time-sensitive in that they apply only to locations and conditions existing at the time of the observation or preparation of this report. Data should not be applied to any other projects in or near the areas of these studies, nor should they be applied at a future time without appropriate verification by qualified individuals.

AECOM has relied on third-party information and interviews with knowledgeable persons for the purpose of preparing this document and is neither responsible for, nor has independently verified the accuracy of this information. AECOM has not performed independent validation or verification of data by others and does not assume any liability for errors or misrepresentations of this third-party information obtained during performance of this work.

This study was performed in a relatively short period of time with the primary goal of providing an independent evaluation and should not be construed as an in-depth analysis of all activities, proffering design concepts, or making design recommendations.

The scope of services performed during this independent evaluation is intended for the sole use of King County and may not be appropriate to satisfy the needs of other users, and any use or reuse of this document, or of the findings, conclusions, or recommendations presented herein is at the sole risk of said user.

Conclusions presented in this report are professional opinions of AECOM team based on available data and information by others.

REFERENCES

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CH2M. 2018 (August). *West Point Treatment Plant Raw Sewage Pump Station Evaluation Viable Alternative Report.*

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APPENDIX A 98 STRATEGIES FROM INDEPENDENT ASSESSMENT

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
1	Table 10 Plant Hydraulics	Evaluate ways to improve control strategies and flow management within the collection system.	Help delay peak flows to West Point.	Under evaluation	2020 Initial Evaluation	WTD regularly considers collection system (pipeline) storage and control strategies when determining how to best manage flows. Storage is typically considered as an option when addressing collection system capacity constraints and is one of the control strategies to be evaluated in the Combined Sewer Overflow (CSO) planning work.
2	Table 10 Plant Hydraulics	Evaluate the collection system to identify new areas for storage.	For example, the Old Fort Lawton Tunnel.	Under evaluation	2020 Initial Evaluation	WTD regularly considers collection system (pipeline) storage and control strategies when determining how to best manage flows. Storage is typically considered as an option when addressing collection system capacity constraints and is one of the control strategies to be evaluated in the CSO planning work.
3	Table 10 Plant Hydraulics	Add primary treatment technologies to the collection system.	Relieve West Point during high flows.	Under evaluation	2020 Initial Evaluation	Adding treatment to the collection system has been and will continue to be considered as part of WTD's future long-term planning efforts. For example, the Georgetown Wet Weather Station that is currently under construction will add primary treatment technology to the collection system. Where appropriate, projects with primary treatment technologies, will be submitted and considered as part of WTD's Six-Year Capital Improvement Plan.
4	Table 10 Plant Hydraulics	Consider implementing passive overflows at key locations.	Passive overflows that do not rely on equipment and controls provide the most failsafe mechanism to protect the plant and workforce.	Under evaluation	2019/2020 Discussion of Options with Regulators	Current state and federal regulations, as well as WTD's 2013 Combined Sewer Overflow federal consent decree with the Washington Department of Ecology and EPA, require WTD to control its overflows to a required standard. During discussions with our regulators in 2019/2020 on West Point's National Pollution Discharge Elimination System permit, WTD will explore options with regulators.
5	Table 10 Plant Hydraulics	Request that West Point Treatment Plant (West Point) be regulated as a combined sewer overflow outfall.	Currently able to discharge to outfalls at other locations. This would require coordination with Department of Ecology.	Under evaluation	Evaluating as part of WTD system-wide planning	Current state and federal regulations, as well as WTD's 2013 CSO federal consent decree with the Washington Department of Ecology and EPA, require WTD to control its overflows to a required standard. During discussions with our regulators in 2019/2020 on West Point's National Pollution Discharge Elimination System permit, WTD will explore with options with regulators.
6	Table 10 Plant Hydraulics	Evaluate maximizing flow through the overflow weir by allowing head to build in the Influent Control Structure.	There is some freeboard above the weir, but flow is limited because of the elevation of the high-high level alarm, triggering the Emergency Bypass gate to open.	Complete	Capital project to start in 2019	WTD completed a project that evaluated the viability and options to construct a passive weir. A project was submitted as part of WTD's Six-Year Capital Improvement Plan. This project will need Ecology approval prior to implementation.
7	Table 11 Influent Control Structure	Evaluate adding a passive bypass weir.	Possibility of using the 84-inch Old Fort Lawton Tunnel to back flow to the Marine Outfall Gate at the Flow Diversion Structure. Utilize upstream storage, if any.	Complete	Capital project to start in 2019	WTD completed a project that evaluated the viability and options to construct a passive weir. A project was submitted and approved as part of WTD's Six-Year Capital Improvement Plan. This project will need Ecology approval prior to implementation.
8	Table 11 Influent Control Structure	Avoid overriding controls of the Emergency Bypass gate to keep the gate manually closed.	None.	Complete	Implemented and ongoing	Standard operating procedures have been revised to ensure controls on the Emergency Bypass gate cannot be overridden except during maintenance.
9	Table 11 Influent Control Structure	Add automated Emergency Bypass gate control at the Influent Control Structure.	Consider adding a second solenoid alarm for redundancy and switching from hardwired interlock controls to control from the Ovation system.	In progress	2019/2020 Implementation	Gate system valves will be upgraded as needed to ensure they meet reliability and safety system standards.
10	Table 11 Influent Control Structure	Add ability to remotely operate Emergency Bypass gate from Main Control.	Provides rapid response without putting operators in harm's way	In progress	1st Qtr 2019 Implementation	As part of the implementation of West Point's life safety system a manual push button will be installed in Main Control to allow remote, emergency opening of the Emergency Bypass and Emergency Marine Outfall gates.
11	Table 11 Influent Control Structure	Add ability to control influent gates from Main Control.	Clogged bar screens could cause water to back up in the Influent Control Structure and trigger the Emergency Bypass gate to open but would not close the influent gates.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system a manual push button will be installed in the main control room to allow remote closure of the influent gates.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
12	Table 11 Influent Control Structure	Add control system programming that closes influent gates automatically when the Emergency Bypass gate is opened.	Clogged bar screens could cause water to back up in the Influent Control Structure and trigger the Emergency Bypass gate to open but would not close the influent gates.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system the influent gates will automatically close as the Emergency Bypass gate opens.
13	Table 11 Influent Control Structure	Install flow meters on influent lines.	Provide an instantaneous direct flow reading that can be utilized for overall plant control.	Not incorporated	N/A	WTD considered whether a flow meter would provide additional information to reduce operational risk and determined it would not reduce risk or improve overall plant control. West Point has a small footprint and relies on lift stations to pump wastewater through the treatment process. This means that West Point relies on level not flow for overall plant control.
14	Table 11 Influent Control Structure	Add real-time collection system controls.	Incorporate historical collection system and watershed data into control strategies.	Complete	Ongoing	WTD considered this recommendation and confirmed that our offsite control system already incorporates real-time control of the collection system. As new collection system facilities come online, WTD will update our real-time control strategies.
15	Table 12 Preliminary Treatment	Continuously rake bar screen area during wet-weather events.	This is opposed to using a differential-level trigger. WTD has made this change.	Complete	Implemented and ongoing	West Point has updated its bar screen standard operating procedures to incorporate this recommendation.
16	Table 12 Preliminary Treatment	Raise the channel height at the bar screen area.	Provides surge protection and increased head in the Influent Control Structure for flow over the passive bypass weir.	Implementing alternative	Alternative capital project to start in 2019	WTD completed a project that evaluated the viability and options to construct a passive weir. The evaluation determined an upstream passive weir (see #6 & #7 above) would best prevent flooding without the need to raise the channel height.
17	Table 13 Raw Sewage Pump Station	Evaluate options to provide 440 mgd firm pumping capacity at raw sewage pumps.	Options and study items could include: 1. Adding a new pump. 2. Replacing existing pumps with new/larger capacity pumps. 3. Increasing the speed of the existing pumps. 4. Changing impellers to provide more flow. This may require a larger engine and modifications to the right-angle gear box. 5. Controlling and limiting collection system flow to the plant at 330 mgd. 6. Considering providing more on-site and/or off-site CSO storage volume.	Complete	Capital project to start in 2019	WTD evaluated all recommendations related to the raw sewage pumps as one single evaluation, including options to increase the capacity of the raw sewage pumps. Changes to the collection system will be evaluated as part of the CSO planning work. A Raw Sewage Pump Improvement project was submitted as part of WTD's Six-Year Capital Improvement Plan.
18	Table 13 Raw Sewage Pump Station	Develop a detailed plan to operate at 330 mgd in preparation for losing a pump.	Not enough firm capacity at raw sewage pumps.	Complete	Implemented and ongoing	West Point Operations is implementing this recommendation as part of a larger Operator training improvement effort. That larger effort includes creating new, and modifying existing, training modules and standard operating procedures.
19	Table 13 Raw Sewage Pump Station	Install flow meters on influent lines.	Provides instantaneous influent flow for faster reaction times during high-flow events (compared to calculating influent flows from the effluent discharge).	Not incorporated	N/A	WTD considered whether a flow meter would provide additional information to reduce operational risk and determined it would not reduce risk or improve overall plant control. West Point has a small footprint and relies on lift stations to pump wastewater through the treatment process. This means that West Point relies on level not flow for overall plant control.
20	Table 13 Raw Sewage Pump Station	Evaluate incorporating automatic controls through a supervisory control and data acquisition (SCADA) system.	Automatically stop pumps based on critical plant high-high water level set points to help prevent flooding.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system the control system will be modified to reduce plant flow when levels are higher than normally allowed.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
21	Table 13 Raw Sewage Pump Station	Provide additional staff training on operating raw sewage pumps.	During peak-flow events and various failure events, more training is needed.	Complete	Implemented and ongoing	West Point Operations is implementing this recommendation as part of a larger Operator training improvement effort. That larger effort includes creating new, and modifying existing, training modules and standard operating procedures as well as implementing an Operator Training Simulator. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
22	Table 13 Raw Sewage Pump Station	Update safety procedures on operating the raw sewage pumps during peak-flow conditions.	Not enough firm capacity at raw sewage pumps.	Complete	Implemented and ongoing	See the response to #21 above. West Point Operations is implementing this recommendation as part of a larger Operator training improvement effort. That larger effort includes creating new, and modifying existing, training modules and standard operating procedures as well as implementing an Operator Training Simulator. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
23	Table 13 Raw Sewage Pump Station	Replace raw sewage pump engines with electric motors. Evaluate current condition of raw sewage pumps and determine expected life span. Provide backup systems to increase redundancy. Evaluate current condition and determine expected life span of the raw sewage pump station [piping system].	Electric motors are more reliable and less expensive to maintain (high initial cost). Plan/budget for equipment maintenance, updates, and replacements. Redundancy reduces opportunity for failure. Estimate pressure capacity, and incorporate corrosion inspections and durability to withstand earthquakes.	Complete	Capital project to start in 2019	WTD evaluated all recommendations related to the raw sewage pumps as one single evaluation, including options to increase the capacity and/or add redundancy to the raw sewage pumps. A Raw Sewage Pump Improvement project was submitted and approved as part of WTD's Six-Year Capital Improvement Plan. Also, WTD's current asset management practices regularly assess, track and report the condition and the end-of-life date for all West Point equipment including the raw sewage pumps.
24	Table 13 Raw Sewage Pump Station	Modify control strategy to include secondary instruments.	Redundancy reduces opportunities for failure. Automatically stop pumps based on critical plant high-high water level set points to help prevent flooding.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system the type, location and redundancy of secondary instrumentation will be reviewed and a replacement plan developed.
25	Table 14 Preaeration and Sedimentation Tanks	Replace level switches with modern tethered switches that do not require a stilling well and are less likely to fail.	WTD has already done this.	Complete	Implemented	Tethered switches were installed during the restoration work at West Point immediately following the February 9 flooding event. These floats have demonstrated greater reliability in industrial settings and can be tested without possibility of damage.
26	Table 14 Preaeration and Sedimentation Tanks	Modify control strategy to include secondary instruments.	Redundancy reduces opportunities for failure.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system the type, location and redundancy of secondary instrumentation will be reviewed and a replacement plan developed.
27	Table 14 Preaeration and Sedimentation Tanks	Incorporate automatic controls through a supervisory control and data acquisition (SCADA) system.	Multilayered control system is not limited to a single interlock control.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system the control system will be modified to reduce plant flow when levels are higher than normally allowed.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
28	Table 14 Preaeration and Sedimentation Tanks	Evaluate feasibility of a passive bypass.	Effluent can be diverted to the Emergency Bypass Outfall within the Flow Diversion Structure.	Implementing alternative	Alternative capital project to start in 2019	This recommendation would provide roughly 30 million gallons of diversion, which would not provide significant relief. Diversion opportunities are being considered at headworks as part of the passive weir project and through the development of West Point's life safety system.
29	Table 14 Preaeration and Sedimentation Tanks	Evaluate feasibility of connecting east and west primary effluent channels.	If one gate fails, near-full utilization of both primary sedimentation basins can continue.	Not incorporated	N/A	Connecting the primary effluent channels would allow primary effluent to flow over one or both gates. The failure of a gate would still result in a capacity reduction and loss of redundancy regardless of which gate failed. Alternatively, construction of a common channel is considered impractical given the existing plant design and site limitations.
30	Table 14 Preaeration and Sedimentation Tanks	Evaluate feasibility of a passive bypass.	Primary Effluent can be diverted to the Emergency Bypass Outfall and 3x3 vent within the Flow Diversion Structure.	Implementing alternative	Alternative capital project to start in 2019	This recommendation would provide roughly 30 million gallons of diversion, which would not provide significant relief. Diversion opportunities are being considered at headworks as part of the passive weir project and through the development of West Point's life safety system.
31	Table 14 Preaeration and Sedimentation Tanks	Reevaluate control strategy.	The control strategy can be based primarily on influent flow measurement, not a series of cascading system levels.	Not incorporated	N/A	WTD considered whether a flow meter would provide additional information to reduce operational risk and determined it would not reduce risk or improve overall plant control. West Point has a small footprint and relies on lift stations to pump wastewater through the treatment process. This means that West Point relies on level not flow for overall plant control.
32	Table 15 Flow Diversion Structure	Evaluate feasibility of a passive bypass.	Options include creating a bypass from the Old Fort Lawton Tunnel or directing primary effluent to the Emergency Bypass Outfall pipe.	Complete	Capital project to start in 2019	WTD completed a project that evaluated the viability and options to construct a passive weir. A project was submitted and approved as part of WTD's Six-Year Capital Improvement Plan.
33	Table 15 Flow Diversion Structure	Add automated Emergency Marine Outfall gate control at Flow Diversion Structure.	Previous practice was to manually override controls at low flow (<250 MGD). The Emergency Bypass gate is now always valved in.	Complete	Implemented and ongoing	Standard operating procedures have been revised to ensure controls on the Emergency Bypass (aka CSO Flow Diversion Gate) and the Emergency Marine Outfall. These gates cannot be overridden except during maintenance.
34	Table 15 Flow Diversion Structure	Add ability to remotely operate Emergency Marine Outfall gate at the Flow Diversion Structure from Main Control.	Provides rapid response without putting operators in harm's way.	Complete	Complete	As part of the implementation of West Point's life safety system a manual push button was installed in Main Control to allow remote, emergency opening of the Emergency Bypass and Emergency Marine Outfall gates.
35	Table 16 Effluent Pump Station	Provide a spare hydraulic unit that can operate with any pump control valve.	Redundancy reduces opportunity for failure.	Complete	Implemented	One spare hydraulic power unit was added to one series of effluent pump station pumps. A capital project installed a hydraulic power unit on the other series. This recommendation also addresses corrective action #1 required by Department of Ecology's Administrative Order.
36	Table 16 Effluent Pump Station	Provide redundant electrical power supply to all hydraulic power units.	Redundancy reduces opportunity for failure.	Complete	Implemented	Automatic transfer switches, to provide redundant power, were installed in mid-2017. This recommendation also addresses corrective action #1 required by Department of Ecology's Administrative Order.
37	Table 16 Effluent Pump Station	Add pressure relief valves at pump discharge lines.	Prevents pump from operating at zero flow/shut-off head conditions if control valve is closed while pump is operating. Discharge flow from pressure relief valves to gravity or pump discharge pipeline.	Implemented alternative	Alternative Complete	This recommendation is not being implemented because it does not address the root cause of the Effluent Pump Station failure nor improve reliability. As an alternative, West Point installed additional hydraulic power units to each Effluent Pump Station pump series.
38	Table 16 Effluent Pump Station	Provide portable ladder platform and hand wheel to manually operate the butterfly control valve.		Implemented alternative	Alternative Complete	This recommendation is not being implemented because a hand wheel would take 30-60 minutes to adjust the valves that need to be opened and closed in seconds for successful operation. As an alternative, a secondary hydraulic power unit on a separate electrical power source was installed to address the root cause of failure that resulted in this recommendation.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
39	Table 16 Effluent Pump Station	Routinely examine data from vibration monitors to determine trends to help forecast pump maintenance and repairs.	None.	Complete	Implemented and ongoing	WTD staff have procured a vendor and will start training staff November 2018.
40	Table 16 Effluent Pump Station	Update vibration monitors.	None.	In progress	1st Qtr 2020 Substantial Completion	An existing capital project is replacing vibration monitors and variable frequency drives for all Effluent Pump Station pumps.
41	Table 16 Effluent Pump Station	Evaluate the current condition of the Effluent Pumping System and determine its expected life span.	Plan/budget for spare parts and equipment maintenance, updates, and replacements.	Complete	Implemented and ongoing	WTD's current asset management practices accomplish this function by assessing, tracking and reporting condition and the end-of-life date for all West Point effluent pumping system equipment.
42	Table 16 Effluent Pump Station	Provide backup systems to increase redundancy.	Redundancy reduces opportunity for failure.	Complete	Implemented and ongoing	Redundancy is being added to critical Effluent Pump Station systems. Staff regularly evaluate current maintenance best practices and will adjust as needed to reduce the risk of equipment and system failures.
43	Table 16 Effluent Pump Station	Provide good maintenance, closely monitor systems, and stock critical spare parts.		Complete	Implemented and ongoing	WTD's current asset management practices require maintenance tracking and system monitoring. WTD's asset management and maintenance best practices accurately predict the critical parts which WTD keeps in stock for the effluent pump station.
44	Table 16 Effluent Pump Station	Use a differential pressure sensor across the pump to estimate flow rate.	An algorithm would be developed that considers pump head/flow curve, pump speed, and pump differential pressure reading. The algorithm can be calibrated using information from the existing effluent flow meter.	Not incorporated	N/A	WTD considered whether developing and calibrating an algorithm would reduce risk or improve overall plant control. We determined this would not provide any additional information beyond what we already receive from the effluent flow meter and would not reduce operational risks.
45	Table 16 Effluent Pump Station	Provide controls that allow the Effluent Pump Station to operate at constant speed.	As a backup, provide controls that allow the pump to operate at constant speed while using the control valve to throttle discharge flow and maintain the wet-well water level set points. This would require adding single-speed starters.	Not incorporated	N/A	This recommendation is not being implemented as it is intended to allow the pumps to operate if the variable frequency drives fail, but does not address the root cause of the failure or improve reliability. West Point has existing equipment redundancy to maintain treatment at full capacity in the event of a variable frequency drive failure.
46	Table 17 Electrical	Incorporate automatic transfer of switchgear main and tie breakers upon power loss.	Provides rapid response for substations that require faster response time than what personnel can provide.	Not incorporated	N/A	This recommendation is not being implemented because the plant's current, comprehensive procedure is required for safety reasons regardless of whether an automatic transfer system was in place. In addition, implementing this recommendation would be complicated, requiring additional structures at a site where space is limited.
47	Table 17 Electrical	Staff at least two electricians during high-flow events.	Two electricians are required for life-safety reasons.	Complete	Implemented and ongoing	WTD now requires electricians and mechanics on standby during weekday evenings and weekends to ensure sufficient coverage during high-flow events.
48	Table 17 Electrical	Provide additional permanently connected hydraulic power unit on the B side.	Include provisions for either unit to power all discharge valves.	Complete	Implemented	One spare hydraulic power unit was added to one series of Effluent Pump Station pumps. A capital project installed a hydraulic power unit on the other series. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
49	Table 17 Electrical	Power Effluent Pump Station discharge valve controls from individual variable-frequency drives.	This is rather than powering from the hydraulic power units.	Implemented alternative	Alternative complete	As an alternative to this recommendation, WTD improved reliability at the Effluent Pump Station by installing permanent hydraulic power units for each of the two sets of pumps, valves and variable frequency drives.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
50	Table 17 Electrical	Analyze single points of failure for all components.	For example, a breaker that would feed control power to all Effluent Pump Station pump controllers or both primary and backup Ovation system controllers.	In progress	2019/2020 Implementation	Points of failure for components that could cause, or prevent, flooding have been analyzed and, where needed, redundancies are being implemented.
51	Table 17 Electrical	Add surge suppressors.	Medium-voltage transient surge suppressors on both sides of the main 15 kV switchgear.	Complete	Implemented	Medium-voltage transient surge suppressors have been installed on both sides of the main 15 kV switchgear.
52	Table 17 Electrical	Install power line monitors with transient waveform capture feature on each substation's main breaker.	A maintenance tool to help analyze power system health and forensic analysis of failures.	In progress	Capital project to start in 2019	A project was submitted as part of WTD's Six-Year Capital Improvement Plan.
53	Table 17 Electrical	Conduct the remainder of testing related to the main switchgear 722-MSG01 circuit breaker ground fault 52-3 trip.	As soon as a plant shutdown is feasible.	Complete	Implemented	WTD completed the testing and changed the ground trip settings based on new, more accurate, modeling information.
54	Table 17 Electrical	Update standard operating procedure for Effluent Pump Station restart after ground fault.	Locally reset Effluent Pump Station vibration panels, variable-frequency drives, and pump local control panels upon a fault.	Complete	Implemented	West Point staff updated the standard operating procedures for the Effluent Pump Station.
55	Table 19 Instrumentation and Control	Add an "Interlock Active" indication light to the local control panels.	Alert the operators when the interlock is engaged (help with troubleshooting).	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system interlock indicator lights will be added to local gate control panels. This will done for all flood prevention gates.
56	Table 19 Instrumentation and Control	Add a supervisory control and data acquisition (SCADA) system bypass switch to bypass the interlock.	This should be available only to the supervisors.	Not incorporated	N/A	The existing interlock is in place for safety reasons and it's unsafe to bypass at any time during regular plant operations. The risk and consequence of another potential flooding event is being reduced by implementing other recommendations.
57	Table 19 Instrumentation and Control	Prevent interlock from being activated during high-plant-flow scenarios.	High-flow events pose a life-safety risk.	Not incorporated	N/A	See the response to #56 above.
58	Table 19 Instrumentation and Control	Remove the requirement to use both the High and high-high switches to activate the interlock.	Only the high-high switch would be required.	Under evaluation	2019/2020 Implementation	As part of the implementation of West Point's life safety system the use of high and high-high level conditions for control will be re-evaluated.
59	Table 19 Instrumentation and Control	Add an Ovation-level high-high signal to the hardwired interlock.	The Ovation signal should be set to activate before the float switches.	Under evaluation	2019/2020 Implementation	See the response to #58 above.
60	Table 19 Instrumentation and Control	Add remote start/stop pump controls to the Main Control room through the Ovation system.	Provides rapid response without putting operators in harm's way.	Implementing alternative	Alternative complete	The existing engines cannot be restarted remotely. Remote start will be considered as part of a future raw sewage pump replacement project. Remote stop capability is being implemented (see response to #61 below).
61	Table 19 Instrumentation and Control	Add a hard-wired emergency stop push button not controlled through Ovation.	Provides rapid response without putting operators in harm's way.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system a manual push button will be installed in Main Control to allow remote, emergency stop of all four raw sewage pumps. This will stop flow through the plant.
62	Table 19 Instrumentation and Control	Add remote start/stop pump controls to the Main Control room through the Ovation system.	Operations must send operators to the raw-sewage wet-well area to locally open/close the gates, taking time and potentially placing operators in harm's way.	Implementing alternative	Alternative complete	See the response to #60 above.
63	Table 19 Instrumentation and Control	Remove the requirement to use both the High and high-high switches to activate the interlock.	Only the high-high switch would be required.	Complete	Capital project to start in 2019	This item is included in the West Point Life Safety Capital Improvement project submitted as part of WTD's Six-Year Capital Improvement Plan.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
64	Table 19 Instrumentation and Control	Add an Ovation-level high-high signal to the hardwired interlock.	The Ovation signal should be set to activate before the float switches.	Under evaluation	2019/2020 Recommendation	See the response to #58 above.
65	Table 19 Instrumentation and Control	Add remote open/close gate controls to the Main Control room through the Ovation system.	Make these controls highly visible to respond in emergencies.	Implementing alternative	Alternative complete	As part of the implementation of West Point's life safety system a manual push button will be installed in Main Control to allow remote, emergency opening of the Emergency Bypass and Emergency Marine Outfall gates. Gates will not be allowed to close remotely. Operations staff is required to physically inspect equipment before gates are closed and equipment is restarted.
66	Table 19 Instrumentation and Control	Conduct an alarm management review workshop to properly prioritize alarms and remove or condition alarms.	The system is not optimized to prioritize alarms	In progress	2018/2019 Implementation	An alarm management review workshop was held and Phase 1 of an alarm management improvement process is currently underway. Pending funding availability, a larger WTD-wide effort (Phase 2) will also be implemented. This recommendation, in addition to #78 and #94, also address corrective action #2 required by Department of Ecology's Administrative Order.
67	Table 21 Staffing	Develop incentive programs to retain staff at West Point.	It is difficult to retain employees at West Point.	Ongoing	Ongoing	Attempts to negotiate incentive pay for new employees at West Point through the 925 bargaining process was unsuccessful in Fall 2017. WTD provided more detail on our ongoing staff retention efforts as part of this West Point Quarterly Report due to Council on February 15, 2018.
68	Table 21 Staffing	Extend aspects of the Operator-in-Training program to existing staff.	Currently the Operator-in-Training Program is only for new hires with no previous wastewater treatment plant experience.	Complete	Implemented and ongoing	WTD-reviewed and updated its standard operating procedures. Operations staff now have 1-on-1 training and more formal communications between crews. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
69	Table 22 Operators	Create an Emergency Bypass standard operating procedure.	If a standardized process is in place, the operators could operate the plant as it is designed.	Complete	Implemented and ongoing	WTD implemented standard operating procedures on use of the Emergency Bypass gate. These procedures will continue to be improved as part of a larger Operator training improvement effort. Also see response to #21.
70	Table 22 Operators	Change the "no bypass" philosophy.	This is important to protect life safety and equipment and to reduce the amount of time the plant is in bypass mode.	Complete	Implemented and ongoing	WTD management has clearly communicated that the Emergency Bypass gate is a tool to be used as required. Operations has instituted new guidelines regarding the appropriate use of the Emergency Bypass gate. Operators are also being trained using desk-top exercises and scenario-based discussions to train on emergency response procedures. In the near future, these exercises will be part of the new simulator training referred to in recommendation #92.
71	Table 22 Operators	Change the "no bypass" philosophy.	Important to keep the environmental protection mission of the organization.	Complete	Implemented and ongoing	See response to #70 above.
72	Table 22 Operators	Add an Emergency Bypass override button at the Main Control room.	Currently this is embedded in the control strategy.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system a manual push button will be installed in Main Control to allow remote, emergency opening of the Emergency Bypass and Emergency Marine Outfall gates.
73	Table 22 Operators	Provide hands-on Emergency Response Plan training.	None.	Complete	Implemented and ongoing	Emergency Response training sessions have been increased from one per year to two. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
74	Table 22 Operators	Run the hydraulic simulation model so operators know narrow time margins and potential consequences.	None.	Complete	Implemented and ongoing	A computer model (simulator) has been developed and deployed. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
75	Table 22 Operators	Implement a Life Safety Management system.	An aspect of this type of process is that it focuses on the process rather than the individual worker to avoid scapegoating and to effectively reduce risk.	Complete	Implemented and ongoing	A Life Safety Coordinator has been hired and an initial Life Safety Evaluation was completed. That evaluation, which will be continuously refined, provides a framework of recommendations that the West Point employees will implement and maintain.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
76	Table 22 Operators	Add an automated call program to contact on-call personnel.	None.	Implemented alternative	Alternative implemented and ongoing	As an alternative, WTD implemented a two-way communication protocol that is required to confirm contact between personnel. A secondary operator is responsible for making calls while the lead operator manages control of the plant.
77	Table 22 Operators	Increase the number of staff on duty in Main Control during wet-weather events.	None.	Complete	Implemented and ongoing	When weather predictions indicate heavy rainfall, the minimum amount of emergency/wet weather staffing has been increased to comply with new high flow protocols and procedures.
78	Table 22 Operators	Conduct an alarm management review workshop to properly prioritize alarms and remove or condition alarms.	The system is not optimized to prioritize alarms.	In progress	2018/2019 Implementation	An alarm management review workshop was held and Phase 1 of an alarm management improvement process is currently underway. Pending funding availability, a larger WTD-wide effort (Phase 2) will also be implemented. This recommendation, in addition to #66 and #94, also address corrective action #2 required by Department of Ecology's Administrative Order.
79	Table 22 Operators	Add a visual beacon/strobe-type alarm in the control room.	To warn the operators in the control room that flooding was imminent unless action is taken.	In progress	2019/2020 Implementation	As part of the implementation of West Point's life safety system visible and audible alarms will be installed in Main Control and Area Control Centers (ACC) 1, 2 and 3. These alarms will notify operators when there is a high liquid level in the galleries and/or a wetwell.
80	Table 22 Operators	Provide Emergency Communications training.	Should be part of Emergency Response Plan training.	Complete	Implemented and ongoing	Operations staff have been trained and Emergency Communications training has been incorporated into the West Point Emergency Response Plan. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
81	Table 22 Operators	Practice standard operating procedures for Effluent Pump Station restart.	This was listed as a step to be checked on the standard operating procedure for Effluent Pump Station restart. Recent issues with EPS pumps have been related to vibration, and based on this previous experience, the operators did not expect power to the valves to be an issue.	Complete	Implemented and ongoing	WTD updated its standard operating procedures and Operations staff have been trained using those updated materials.
82	Table 25 Training	Create a designated emergency evacuation path.	Train often on designated emergency evacuation path.	Complete	Implemented and ongoing	A designated emergency evacuation path exists and this has been reinforced and emphasized in the Emergency Response Plan.
83	Table 25 Training	Develop standard operating procedure for tunnel entry.	Develop a standard operating procedure for tunnel entry, particularly to avoid entering at high flows.	Complete	Implemented and ongoing	Immediately following the flood event, WTD implemented standard operating procedures to limit, and closely monitor, tunnel entry by employees during periods of high flows. As part of a continuous improvement effort, West Point employees are evaluating how best to update existing communication protocols and where to install visual alarm indicators within the tunnels. This work is being done as part of the life safety management system implementation.
84	Table 25 Training	Review operator training program.	Need to assess the appropriateness and amount of training provided.	Complete	Implemented and ongoing	West Point implemented weekly training with a technical trainer and updated training materials. In addition, Operation staff conduct daily training and lessons learned sessions within and between crews. This recommendation also addresses corrective action #5 required by Department of Ecology's Administrative Order.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
85	Table 25 Training	Increase number of operators on duty.	Operators need time on nonemergency shifts to gain on-the-job training across the plant.	Complete	Implemented and ongoing	Operations vacancies have been filled. WTD has also expanded its existing training program to improve the number and quality of candidates for future vacancies. This was done by hiring additional 15 additional operator-in-training and term-limited temporary (TLT) staff who will be trained and eventually hired into career service positions. Additionally, West Point has updated standard operating procedures and increased the type and frequency of operator training. West Point employees continues to evaluate how to improve all training, especially emergency response, and will implement training improvements as they are developed.
86	Table 25 Training	Provide hands-on Emergency Response Plan training.		Complete	Implemented and ongoing	Emergency Response training sessions have been increased from one per year to two. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
87	Table 26 Equipment and Systems Testing	Add waterproof lighting in the basement.		Implemented alternative	Alternative complete	As an alternative to this recommendation, WTD implemented revised standard operating procedures that limit and monitor tunnel entry during periods of high flow.
88	Table 26 Equipment and Systems Testing	Have two permanent skids hooked up at all times.	Have online but connected.	Complete	Implemented	One spare hydraulic power unit was added to one series of Effluent Pump Station pumps. A capital project replaced the temporary installation for the one on the other series of pumps. This recommendation also addresses corrective action #1 required by Department of Ecology's Administrative Order.
89	Table 26 Equipment and Systems Testing	Secure walkway covers.	Fixed.	Complete	Implemented	Walkway covers have been bolted down.
90	Table 26 Equipment and Systems Testing	Revise standard operating procedure for annual plant hydraulic safety.	It was done this way because of multiple tank leaks experienced when water levels are above normal. This has been fixed.	Complete	Implemented and ongoing	A review and update of standard operating procedures has been completed and float testing is scheduled for twice a year.
91	Table 26 Equipment and Systems Testing	Implement a Life Safety Management system.	A Life Safety Management system should be developed and implemented to reduce risks and improve safety for the staff at the plant, protect the equipment, and reduce the duration of bypass events.	Complete	Implemented and ongoing	A Life Safety Coordinator has been hired and an initial Life Safety Evaluation was completed. That evaluation, which will be continuously refined, provides a framework of recommendations that the West Point employees will implement and maintain.
92	Table 26 Equipment and Systems Testing	Develop a dynamic computer model to simulate plant hydraulic conditions.		Complete	Implemented and ongoing	A computer model (simulator) has been developed and deployed. This recommendation also addresses corrective action #4 required by Department of Ecology's Administrative Order.
93	Table 26 Equipment and Systems Testing	Implement routine testing of the Primary Effluent gate interlock indicator in Area Control Center 1.		Complete	Implemented and ongoing	West Point Maintenance employees will conduct an interlock test as part of their annual float testing procedure.
94	Table 26 Equipment and Systems Testing	Conduct an alarm management review workshop to properly prioritize alarms and remove or condition alarms.	Alarm criticality ratings should be reviewed. Only life-safety/hydraulic protection–related alarms should be classified as criticality level 1. These alarms should remain visible until cleared.	In progress	2018/2019 Implementation	WTD is developing an initial list of criticality level 1 alarms. This list will be revised as part of the development of West Point's life safety system. This recommendation in addition to #66 and #78 also address corrective action #2 required by Department of Ecology's Administrative Order.

#	AECOM Table #	AECOM Recommendations	AECOM Comments	Status	Timeline	WTD Response to Council
95	Table 26 Equipment and Systems Testing	Revise standard operating procedure for Effluent Pump Station reset.	Need to specify the amount of time operators have during different flow conditions. Standard operating procedure specifies 2 attempts for restart.	Complete	Implemented and ongoing	WTD implemented a standard operating procedure for the Effluent Pump Station that specifies two restart attempts and updated training also emphasizes that procedure.
96	Table 27 Maintenance Procedures	Implement a Life Safety Management approach to all maintenance not included in Process Safety Management.	Implement a Life Safety Management approach to all maintenance not included in Process Safety Management.	Complete	Implemented and ongoing	A Life Safety Coordinator has been hired and an initial Life Safety Evaluation was completed. That evaluation, which will be continuously refined provides a framework of recommendations that the West Point employees will implement and maintain.
97	Table 27 Maintenance Procedures	Implement a Life Safety Management approach to all maintenance not included in Process Safety Management.	Maintenance may negatively affect component performance if the execution is incorrect, insufficient, delayed, or excessive.	Complete	Implemented and ongoing	A Life Safety Coordinator has been hired and an initial Life Safety Evaluation was completed. That evaluation, which will be continuously refined, provides a framework of recommendations that the West Point employees will implement and maintain.
98	Table 27 Maintenance Procedures	Implement a Life Safety Management approach to all maintenance not included in Process Safety Management.	Organized communication is a component of a Life Safety Management system.	Complete	Implemented and ongoing	A Life Safety Coordinator has been hired and an initial Life Safety Evaluation was completed. That evaluation, which will be continuously refined, provides a framework of recommendations that the West Point employees will implement and maintain.

APPENDIX B SUMMARY OF DOCUMENTATION PROVIDED BY WTD

Author	Title	Date
Emerson Automation Solutions	King County Advanced Alarm Management Emerson Process Management Power & Water Solutions, Inc. Offer No. WAM17090179 Rev4	April 2018
Emerson Automation Solutions	PHASE 1 ALARM MANAGEMENT INSTALLATION PLAN KING COUNTY WASTEWATER – BRIGHTWATER	November 2018
Emerson Automation Solutions	PHASE 1 ALARM MANAGEMENT INSTALLATION PLAN KING COUNTY WASTEWATER – SOUTH PLANT	September 2018
Emerson Automation Solutions	PHASE 1 ALARM MANAGEMENT INSTALLATION PLAN KING COUNTY WASTEWATER – WEST POINT	September 2018
KC WTD and Emerson Automation Solutions	Alarm Management Philosophy	June 2018
Emerson Automation Solutions	STATIC RATIONALIZATION REVIEW KING COUNTY WASTEWATER: WESTPOINT	June 2018
Emerson Automation Solutions	KICK-OFF & WORKSHOP AGENDA KING COUNTY WASTEWATER: ALARM MANAGEMENT	March 2018
KC WTD	CS-70001 – WPTP Flood Prevention Safety System	October 2018
CH2M	West Point Treatment Plant Raw Sewage Pump Station Evaluation Viable Alternative Report	August 2018
CH2M	West Point Treatment Plant Flood Prevention Safety Requirements Specification	October 2018
CH2M	WPTP – Flood Prevention Basis of Design, 90% Design	October 2018
KC WTD	Incident Command System & Emergency Response (Presentation)	N/A
CH2M	West Point Treatment Plant Flood Protection System Risk Analysis	November 2017
KC WTD	West Point - Life Safety Management Kick Off Meeting and Review	January 2018
KC WTD	WPTP: Filling, Processing, and Submitting O&M Request for Change Forms	N/A
KC WTD	West Point Treatment Plant Emergency Overflow Passive Bypass Weir Feasibility Study	May 2018
Waddle	West Point Emergency Outfall Gate Operating Procedure Draft Memorandum	September 2017
KC WTD	WEST POINT EMERGENCY OUTFALL (EB/EMO) GATE OPERATING PROCEDURE	November 2018
KC WTD	HOW TO OPERATE THE EMERGENCY MARINE OUTFALL (EMO) GATE AT FDS AND THE EMERGENCY BYPASS (EB) GATE AT ICS	November 2018
KC WTD	HOW TO ISOLATE THE HYDRAULIC GATE ACCUMULATORS AND ACTUATORS	November 2018
KC WTD	HOW TO OPERATE THE INFLUENT GATES AT ICS	November 2018
KC WTD	HOW TO ISOLATE THE HYDRUALIC PUMPS ON THE FLUID POWER SKID AT ICS	September 2018
KC WTD	West Point Treatment Plant - High Flow Management	December 2018
KC WTD	WPTP - Critical Elevations and Set Points	December 2018
KC WTD	West Point Treatment Plant – Restart Procedures after a Power Outage	November 2018
KC WTD	HOW TO OPERATE THE EFFLUENT PUMPS	July 2002
KC WTD	HOW TO RESET AFTER A SEAL WATER PRESSURE LOW ALARM FAILURE	November 2017

Author	Title	Date
KC WTD	HOW TO RESET THE PUMP DISCHARGE PRESSURE CONTROL VALVE FIELD PANEL - EPS	July 2018
KC WTD	HOW TO RESET EPS PUMP 1 AND PUMP 2 VARIABLE FREQUENCY DRIVES (VFD)	December 2018
KC WTD	HOW TO RESET THE TEMP/VIBRATION MONITOR - EPS	July 2018
KC WTD	HOW TO RESET A DISCHARGE CONTROL VALVE HYDRAULIC PUMP - EPS	July 2018
KC WTD	HOW TO CLEAN THE SEAL WATER STRAINER - EPS	July 2018
KC WTD	CONTROL STRATEGIES AND GUIDELINES – RAW SEWAGE PUMP BUILDING – FACILITY 704	December 2018
CH2M	West Point Treatment Plant Raw Sewage Pump Station Evaluation Viable Alternative Report	August 2018
KC WTD	Investing In You Training “Maintenance Training Packet” EPS Hydraulic Power Unit (HPU) Training & Quiz	November 2018
KC WTD	Emergency Operator Training Packet	N/A
KC WTD	Investing in You Training	N/A
KC WTD	Emergency Action Plans for Plant Operations and Maintenance Personnel	December 2013

APPENDIX C BYPASS TECHNICAL MEMORANDUM

M e m o r a n d u m

Date: September 15, 2017

Subject: **DRAFT - West Point Emergency Outfall Gate Operating Procedure**

From: Robert Waddle, WTD Operations Manager

To: Mark Isaacson WTD Director

Here is our first cut at developing guidelines on when the Emergency Bypass Gate must be opened by the Shift Supervisor at the West Point Treatment plant.

Emergency Opening of the Emergency Bypass (EB) Gate

A potential exists where the manual opening of the EB/EMO gates may be required. The manual operation of either gate will be a decision based upon the best judgment at the time of the Incident Commander (Shift Supervisor or their designee) in an emergency situation. Below are several "general" scenarios where manual use of the gates may be needed:

Scenario 1

A complete loss of power (both sides A and B) at the West Point Treatment Plant (WPTP): This decision is flow and influent level dependent that must be a major consideration when weighing the option of using either the EB or EMO gate.

- Influent flow greater than 300 MGD and an influent wet well level greater than 109 feet
  - Open EB and EMO gates immediately
  - Close the influent gates immediately
  - EB and EMO gates remain open until power and pumping is reestablished
- Influent flow less than 300 MGD
  1. When EPS interlocks activate primary gate closure, monitor primary levels.
  2. When primary level reaches 119.6 initiate manual shutdown of RSP's
  3. Immediately manually open the EB and EMO gates.
  4. Close the influent gates immediately
  5. Steps 2 and 3 will not be required if the primary and influent wet well float interlocks activate as designed. The Incident Commander shall not rely solely on the interlocks to open the gates and shall monitor and open the gates manually if the interlocks fail.

Scenario 2

A loss of a major pumping station (Influent and/or Effluent Pump Stations) within WPTP: This decision is somewhat flow dependent and influent flow must be a major consideration when weighing the option of using either the EB or EMO gate.

- Influent flow greater than 300 MGD and an influent wet well level greater than 109 feet
    - Open EB and EMO gates immediately
    - Gate remain open until power and pumping is reestablished
- Influent flow less than 300 MGD
    1. When EPS interlocks activate primary gate closure, monitor primary levels.
    2. When primary level reaches 119.6 initiate manual shutdown of RSP's
    3. Immediately manually open the EB and EMO gates.
    4. Steps 2 and 3 will not be required if the primary and influent wet well float interlocks activate as designed. The Incident Commander shall not rely solely on the interlocks to open the gates and shall monitor and open the gates manually if the interlocks fail.

Scenario 3

A toxic or explosive substance spill entering the conveyance system: In order to protect the plant's biological processes or to protect life and safety from toxic spills may require the immediate use of the EB/EMO gate

- Fully open EB Gate
- Shutdown all hydraulic pumping (RSP, IPS, EPS)
- Clear spill from process
- Verify spill material is no longer toxic or is below LEL
- Restart plant pumping
- Close EB gate

Scenario 4

An individual falling into an active part of the liquids stream within the plant: In order to perform rescue or recovery within a WPTP process flow:

- Fully open EB Gate
- Shutdown all hydraulic pumping (RSP, IPS, EPS)
- Search for missing person
- Recover person
- Restart plant pumping
- Close EB gate

Again, the decision would be flow dependent meaning that a low flow day may allow for several hours of storage time whereas high flow days may require immediate action.

After an incident that required the use of the EB or EMO gates is under control, the Incident Commander shall follow the procedures and make the necessary notifications described in the Overflow Manual.