HDR

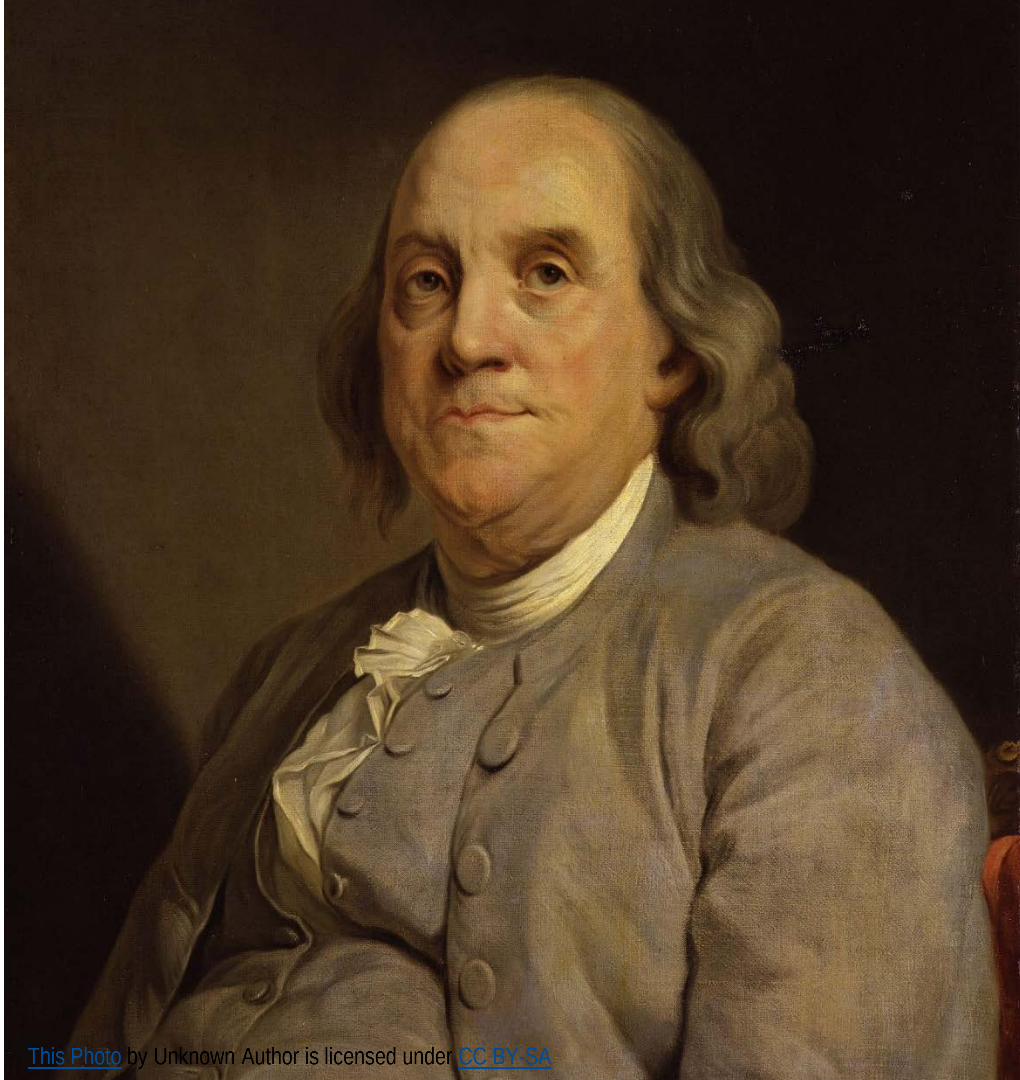
HYDROLOGIC ENGINEERING MANAGEMENT PLANS

A key component to FIRO success

HDR

WHAT IS A HYDROLOGIC ENGINEERING MANAGEMENT PLAN (HEMP)?

- Hydrologic engineer's focused equivalent of project management plan (PMP).
- Corps' guidance in EP 1110-2-9 (*Hydrologic engineering studies design*, 1994):
  - The HEMP is a technical outline of the hydrologic engineering studies necessary to formulate a solution to a water resource problem.
  - The use of a hydrologic engineering management plan is threefold…(a) Basis for firm time and cost estimates; (b) Technical guide for the hydrologic engineer; (c) review contract.



WHAT'S IN A HEMP?

- Study objective
  - What are we trying to accomplish?
- Type of study
  - What are we analyzing?
- Key items to evaluate
  - What are the majors issues?
  - What is the appropriate level of detail?
  - What data/information are available?
  - Are there unusual features/considerations that must be addresses?
  - What are the study/project boundaries?
  - What are the defined/likely alternatives?
- Major Hydrologic Engineering Activities Required
  - What are the details of the study components?
- Primary Hydrologic Engineering Investigation Products
  - What is the final product?

WHAT'S THE PURPOSE OF A HEMP?

- *Initial* HEMP – defines key issues and activities sufficient to address study time and cost.
- *Detailed* HEMP – outlines significant technical activities in sufficient detail for the responsible engineer to perform the analysis.

INITIAL HEMP

Used to establish total hydrologic engineering cost for inclusion in the initial PMP

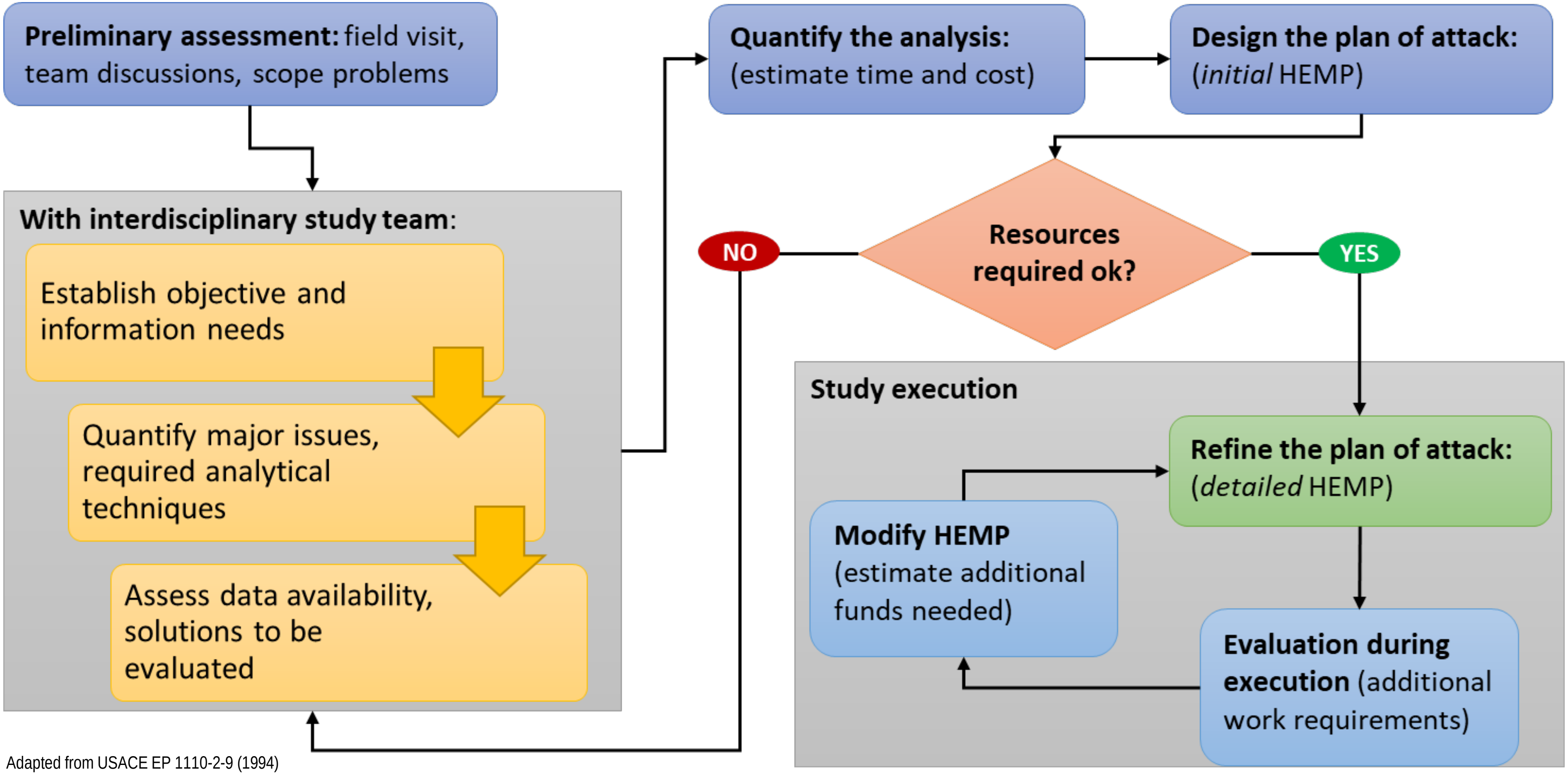
- Field inspection
- Coordination (study team & stakeholders)
- Data/information collections
- Best analysis approaches
- Schedule estimates
- Cost estimates
- Stakeholder agreement

DETAILED HEMP

Step-by-step procedures and methods to complete the study

- Specific analysis details
- Detailed schedule and defined project milestones
- Documentation and reporting requirements

HEMP DEVELOPMENT



Adapted from USACE EP 1110-2-9 (1994)

LAKE MENDOCINO FIRO FULL VIABILITY ASSESSMENT (FVA)

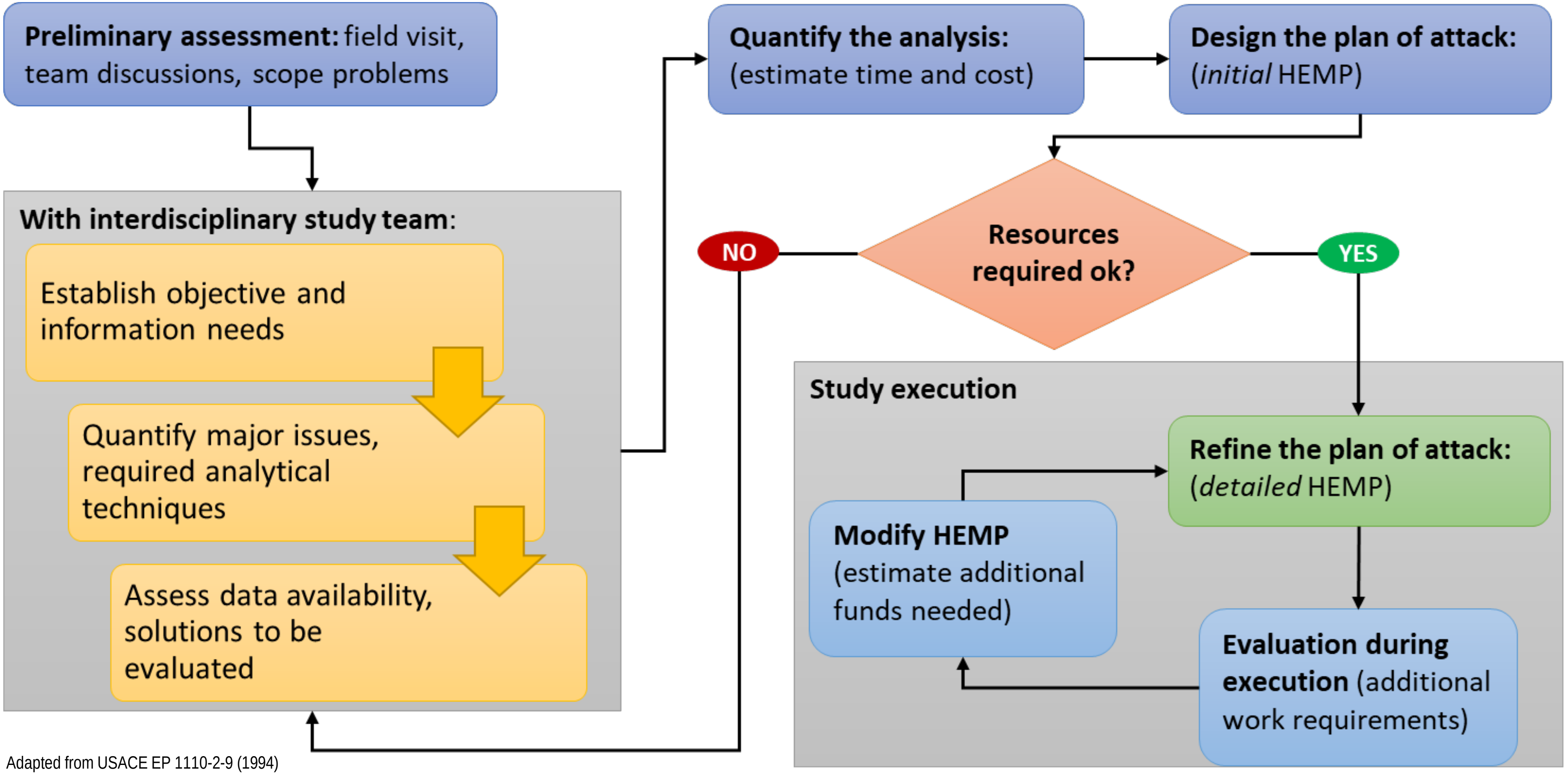
A HEMP case study

Characteristic	Description
Drainage area	105 sq. miles
Climate	• 93% of precip Oct-May • 3-4 major winter storms • 30%-50% from ARs
Summer conservation storage	111,000 ac-ft
Winter conservation storage	68,400 ac-ft
Max flood space	48,100 ac-ft

PURPOSES OF HEMP FOR LAKE MENDOCINO FIRO FVA

- Identify objective and requirements for the analysis required to support FIRO.
- Identify tasks to be completed.
- Identify analysis tools and methods to be used.
- Identify project team members responsible for conduct, review, and approval of the hydrologic engineering study.
- Provide analysis schedule.

HEMP DEVELOPMENT



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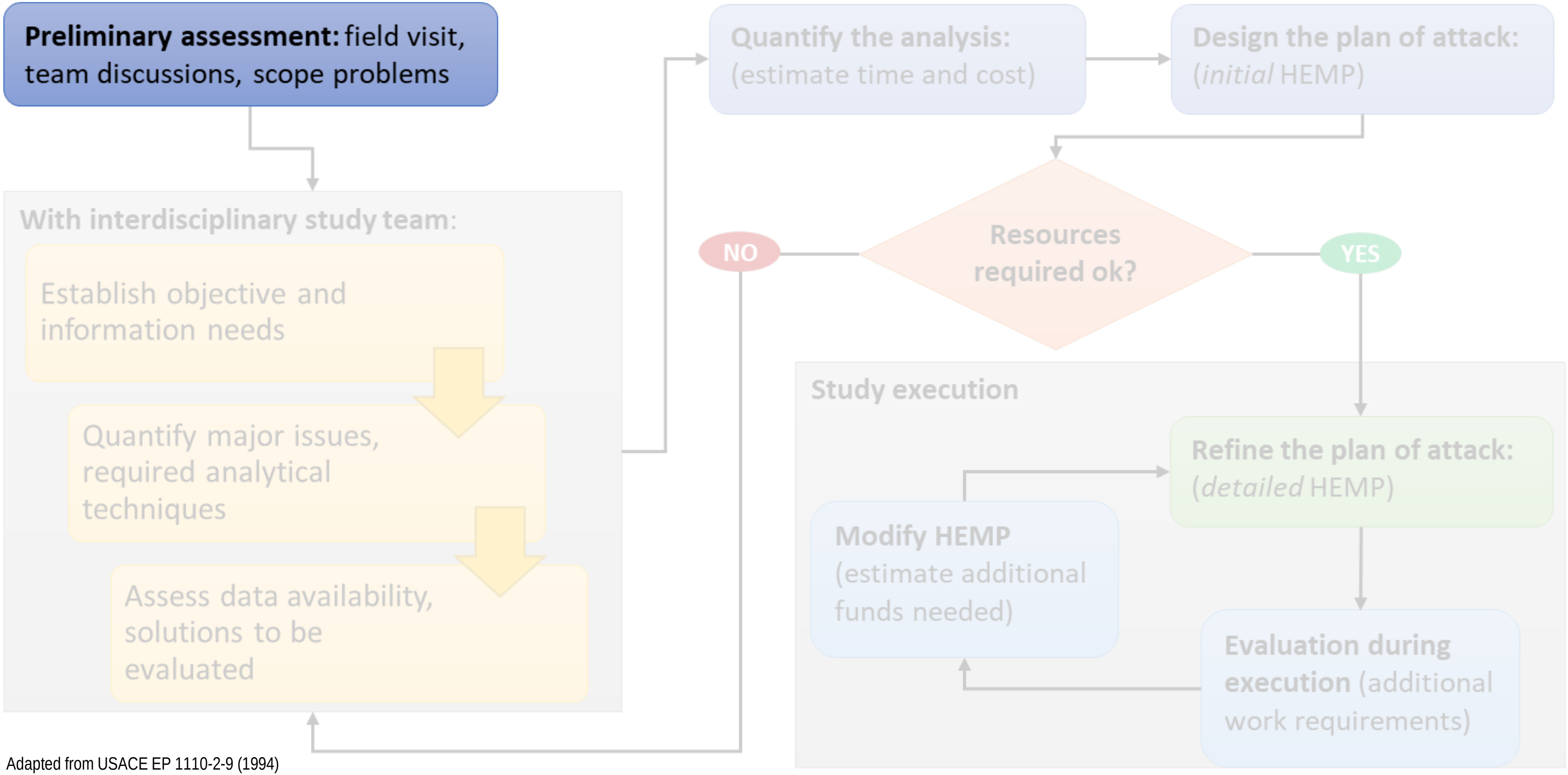
HEMP DEVELOPMENT



Adapted from USACE EP 1110-2-9 (1994)

Preliminary assessment: field visit, team discussions, scope problems

PROJECT DELIVERY TEAM (PDT)

- FIRO management team
- SWA technical staff
- USACE HQ staff
- USACE HEC staff
- USACE ERDC staff
- USACE SPK and SPN staff
- Rob Hartman
- HDR staff

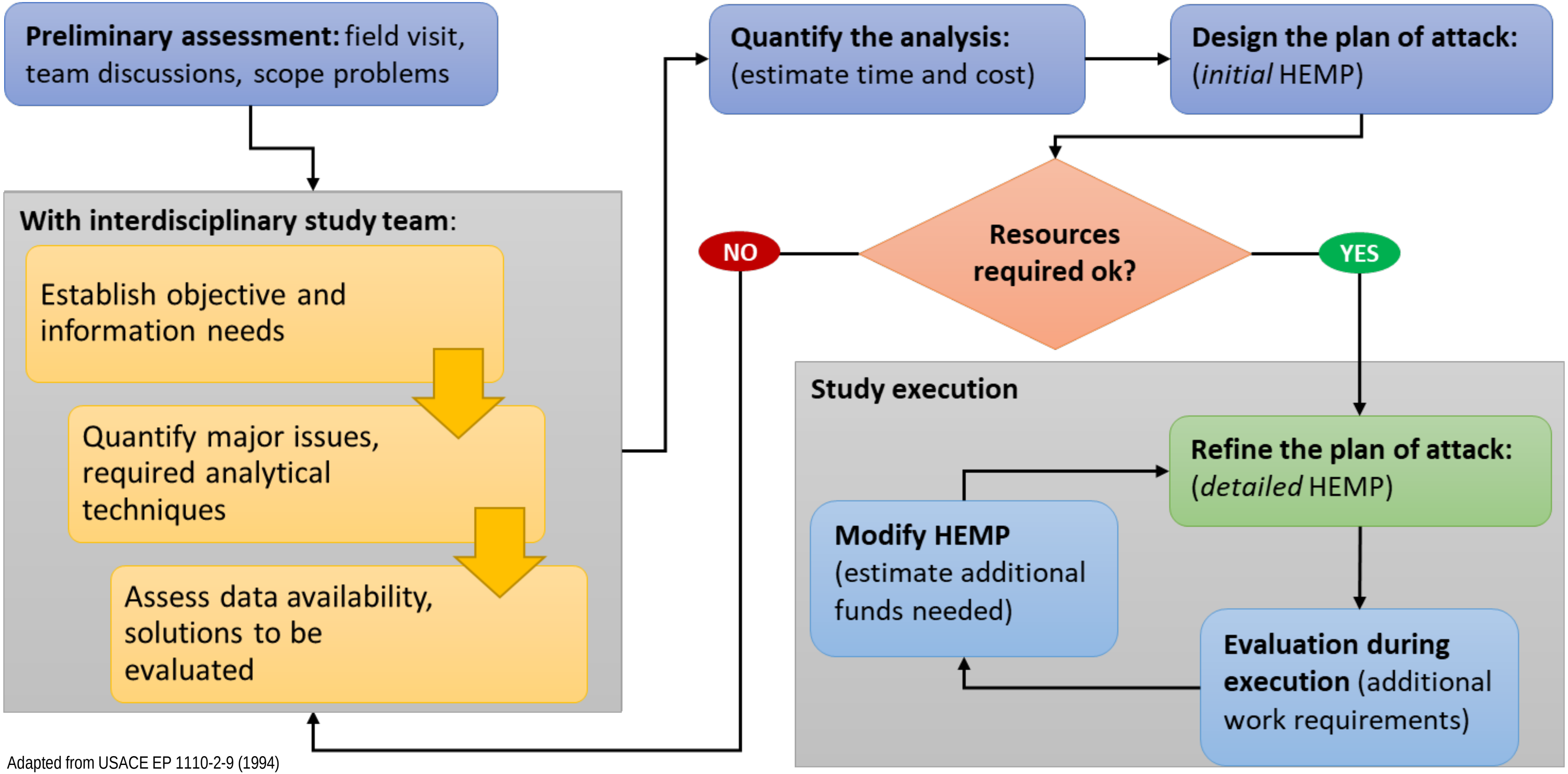
Source: https://cw3e.ucsd.edu/firo-preliminary-viability-assessment-for-lake-mendocino/

Preliminary assessment: field visit, team discussions, scope problems

RISKS TO SUCCESS OF STUDY

Potential failure mode (1)	Actions PDT can take to mitigate (2)
Simulation or evaluation software does not function as expected.	Limit analysis to use of software that is readily available and has been stress tested.
Necessary data–including hydrological, meteorological, water use, vulnerability—are not readily available.	Limit analysis to use of best-available data.
Key personnel are not available to complete tasks.	Ensure back up staff for all critical tasks.
Critical path tasks fall behind schedule due to unforeseeable distractions and disruptions.	Limit project activities to those that are necessary to satisfy objectives, deferring any research and development (for example).
PDT disagrees about technical analysis procedures.	Defer to RACI assignments.
Nature of alternative FIRO strategy prevents evaluation with selected metrics.	Disqualify alternative from further consideration unless metrics can be adjusted and applied in uniform manner for all alternatives.

HEMP DEVELOPMENT



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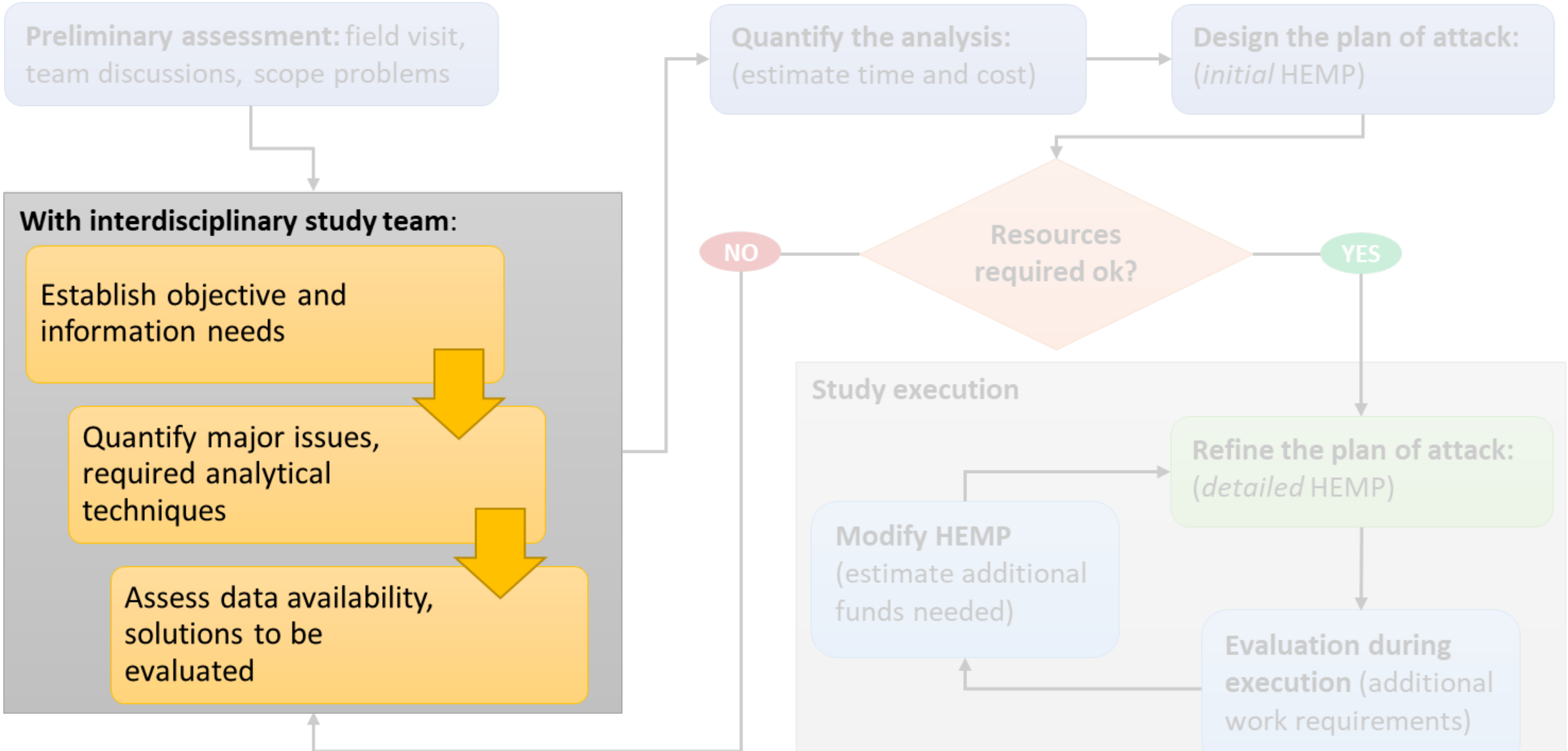

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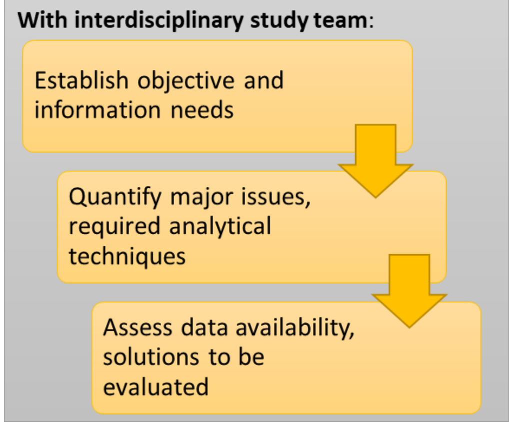
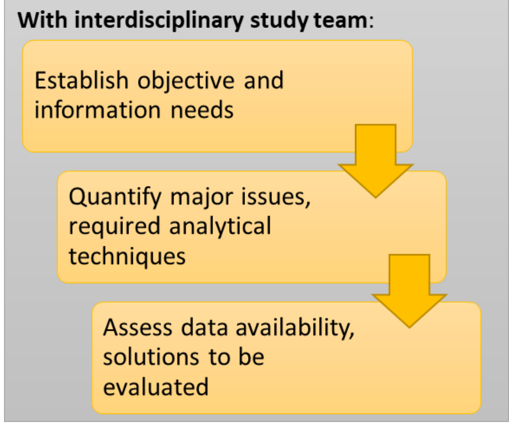


OBJECTIVE AND REQUIREMENTS

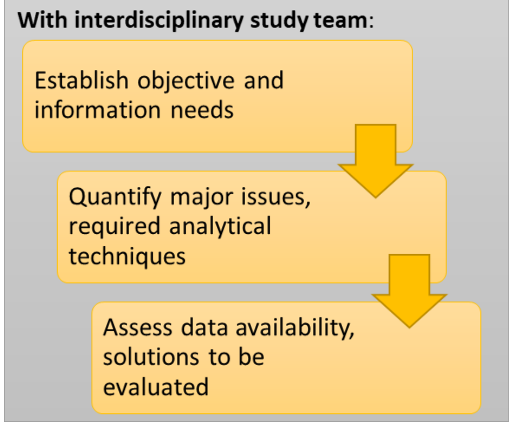
- Objective: Identify and recommend to Lake Mendocino FIRO steering committee—through systematic, defendable, repeatable technical analysis—an efficient, acceptable FIRO strategy for Lake Mendocino
- Requirements:
  - Satisfy relevant USACE engineering regulations (ERs)
  - Limit analytical tools to USACE certified software
  - Measure improvements attributable by comparing to water control plan included in current manual
  - Use streamflow California-Nevada River Forecast Center forecasts
  - Satisfy limiting conditions regarding operation
  - Use existing software



HEMP TASKS AND SUBTASKS

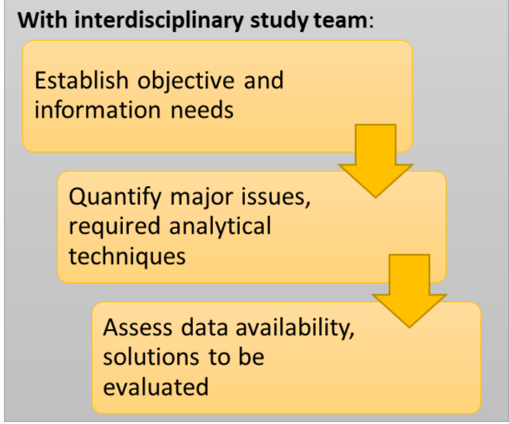
- Select performance measures
- Nominate/formulate alternative FIRO strategies that will be considered
- Conduct side studies
- Simulate performance with each alternative
- Using results of simulation, evaluate each alternative in terms of the identified performance measures
- Compare the alternatives by comparing metrics
- Brief SC on findings and facilitate the selection of a preferred alternative

PERFORMANCE MEASURES (METRICS): FLOOD RISK MANAGEMENT



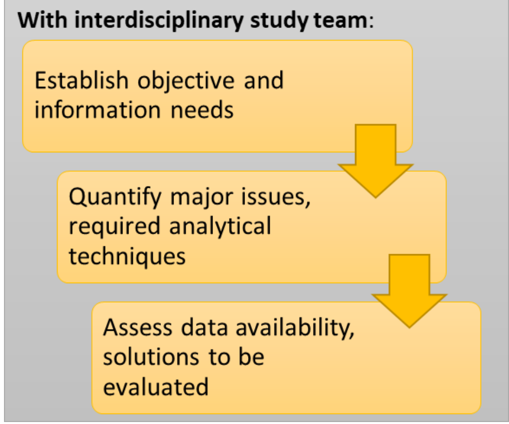
1. Annual maximum flow frequency function at Hopland, Healdsburg, and Guerneville
2. Annual maximum pool elevation frequency function of Lake Mendocino
3. Annual maximum pool elevation frequency function of Lake Sonoma
4. Annual maximum Lake Mendocino total release frequency function
5. Annual maximum Lake Sonoma total release frequency function
6. Annual maximum uncontrolled spill frequency function for Lake Mendocino
7. Annual maximum uncontrolled spill frequency function for Lake Sonoma
8. Expected annual inundation damage at critical Russian River locations
9. Expected annual potential (statistical) loss of life due to floodplain inundation, critical Russian River locations

PERFORMANCE MEASURES (METRICS): WATER SUPPLY AND ENVIRONMENTAL



10. Reliability of water supply delivery, as measured by annual exceedance frequency of May 10 reservoir storage levels
11. Ability to meet in-stream flows to support threatened and endangered anadromous fish species during the summer rearing season, as measured by number of days June through September flows exceed the 125 cfs target established by the 2008 Biological Opinion in the Upper Russian River
12. Ability to meet in-stream flows to support fall spawning migration of threatened Chinook salmon, as measured by number of days October 15 to January 1 flows exceed minimum spawning migration passage flow of 105 cfs

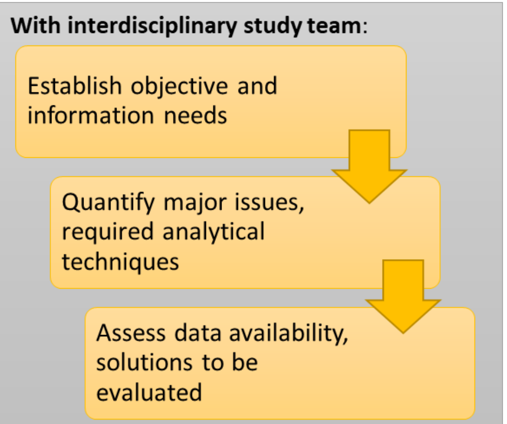
PERFORMANCE MEASURES (METRICS): RECREATION, POWER, DAM SAFETY, OPERATIONS



13. Impacts to the Bushay Campground access during the recreation season (Memorial Day weekend through Labor Day weekend)
14. Impacts to power production of the CVD powerhouse
15. Lake Mendocino bank protection, as measured by annual frequency of exceeding elevation 758.8 ft. (Bank protection in Lake Mendocino is limited above this because of limited riprap. USACE prefers to avoid long-term storage in this range.)
16. Impacts to hours of operation

WCP ALTERNATIVES

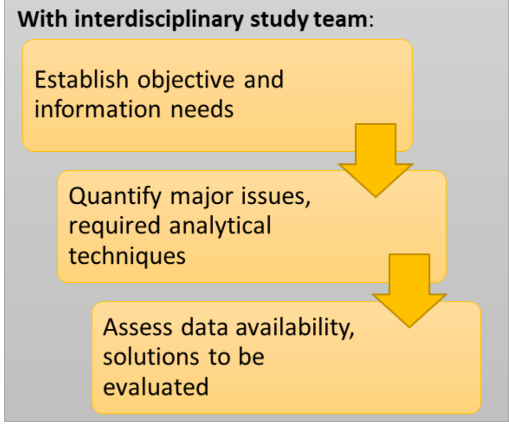
- Baseline WCM Operations
- Full EFO
- WY 19/20 Major Deviation Hybrid
- Modified Hybrid with “corner cut” on 2/15
- Folsom-like
- 5-day Deterministic Forecast



ID (1)	Alternative strategy (2)	Description (3)
1	Existing WCP operation (Baseline)	This is the baseline condition against which performance of all alternatives will be measured. It includes the seasonal rule curves and release selection rules from the 1986 USACE WCM and 2004 update to the flood control diagram (FCD). This plan calls for winter season storage of 68,400 ac-ft and a summer storage of 111,000 ac-ft with fall and spring drawdown and refill (see standard rule curve). No forecasts are utilized. Storage above the rule curve is always evacuated as quickly as feasible.
2	Ensemble Forecast Operations (EFO)	Uses the 15-day ensemble streamflow forecasts from the CNRFC. Assesses the probability of storage above 111,000 ac-ft (model parameter) given the inflow ensembles and a release schedule and compares this with a probability threshold defined through calibration. If probability exceeds the tolerable likelihood anywhere in the 15-day period, a flood release is computed to reduce the probability to an acceptable level. Recommended release can be updated with each forecast cycle.
3	WY19 hybrid (Major Deviation #1)	A combination of the existing WCP and the EFO where the variable space is managed by the EFO process. In mid-winter the variable space resides between 68,400 and 80,050 ac-ft and maintains the same drawdowns and refill start dates as the WCP. Storage above the variable space is always evacuated as quickly as feasible. (See Major Deviation #1 rule curve.) Recommended release can be updated with each forecast cycle.
4	Additional hybrid(s)	To be detailed in Task 2. Similar to WY19 hybrid, with higher mid-winter storage and/or a corner cutting adjustment in March to aid with spring refill. More than one variant of this strategy may be evaluated.
5	Folsom-like	Creates a variable flood control space above 68,400 ac-ft and below a storage to be identified in Task 2 that is managed in proportion to the 5-day ensemble inflow at an exceedance probability level as issued by the CNRFC (also to be identified in Task 2). The current storage and inflow forecast determine the target storage and the appropriate reservoir release. Storage above the variable space is always evacuated as quickly as feasible. Recommended release can be updated with each forecast cycle.
6	5-day single-value based	To be determined by SPN and HEC. Allowable storage above 68,400 ac-ft and reservoir release informed by current storage and the 5-day single-value forecast for Lake Mendocino inflow, the Russian nr Ukiah, and the local above Hopland as issued by the CNRFC. Recommended release can be updated with each forecast cycle.

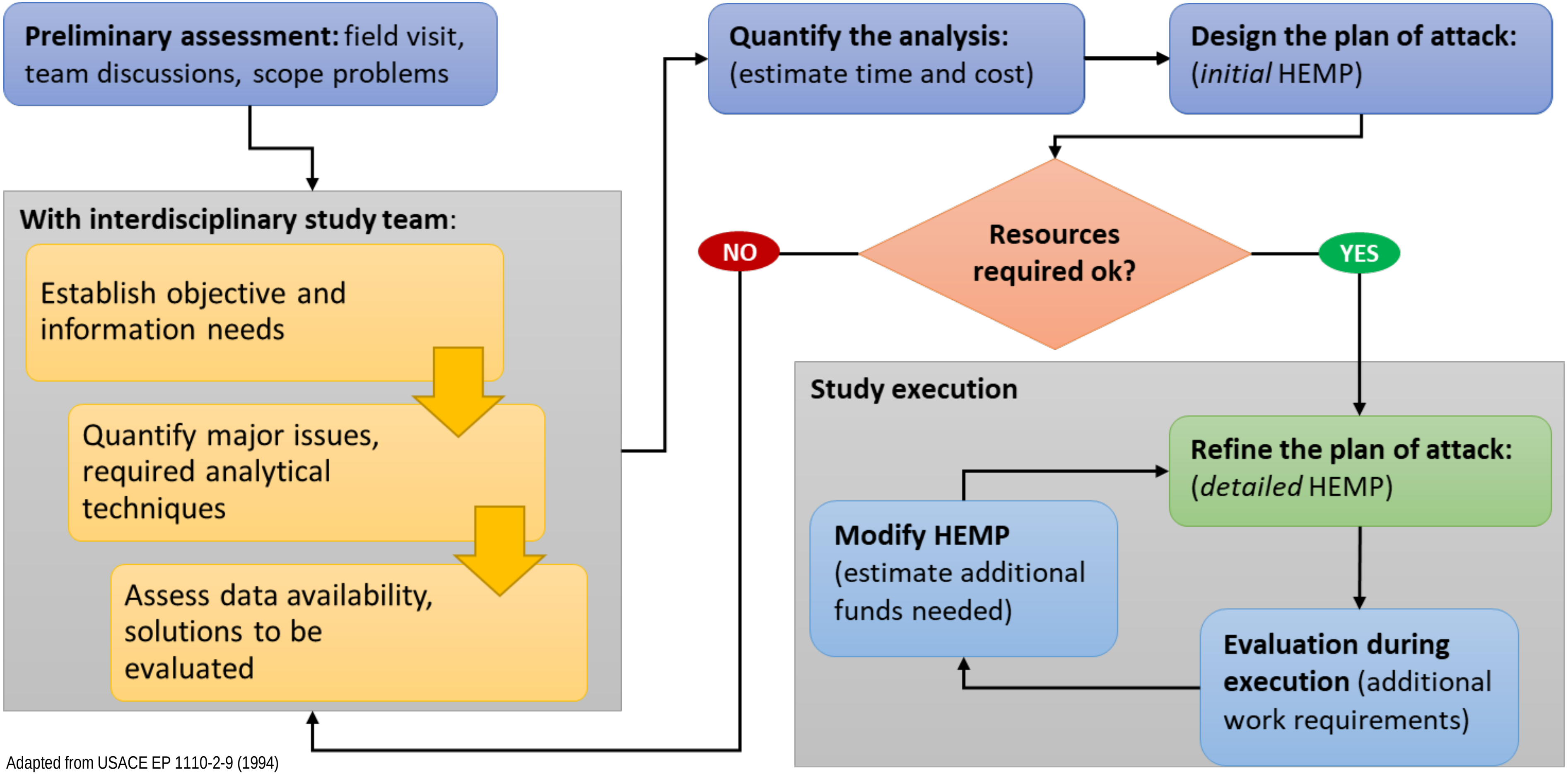
ANALYSIS BOUNDARY CONDITIONS

- Period of record (POR) ~ 33 years
  - Hindcasts for 1/1/1985 through 9/30/2017.
  - Largest annual events for water year (WY) 1985 to WY 2017
- Design events
  - CNRFC created 8 design events:
    2 scalings of 4 historic event patterns.
  - Represent events rarer than those seen in the hindcast period.



ID	Pattern	AEP/Scaling
1	1986	p=0.005 (200-year)
2	1986	p=0.002 (500-year)
3	Mar 1995	p=0.005 (200-year)
4	Mar 1995	p=0.002 (500-year)
5	1997	p=0.005 (200-year)
6	1997	p=0.002 (500-year)
7	2006	p=0.005 (200-year)
8	2006	p=0.002 (500-year)

HEMP DEVELOPMENT



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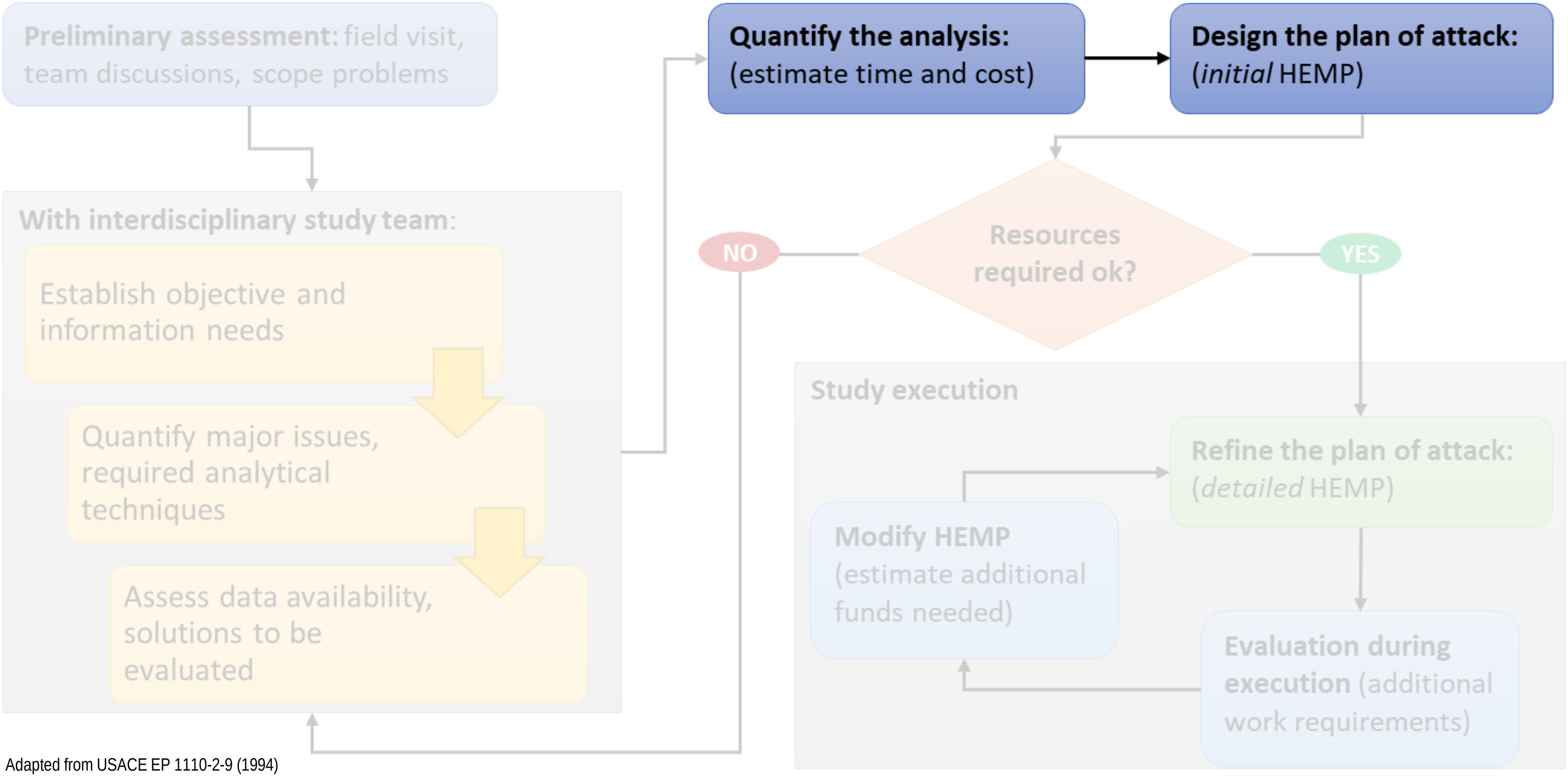

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LAKE MENDOCINO FIRO HEMP

Task	2019						2020											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T1. Select metrics	■																	
T2. Nominate/formulate alternatives	■																	
T3. Simulate	■	■	■	■			■											
T4. Evaluate					■	■												
T5. Compare								■	■	■								
T6. Select and recommend											■	■						

Hydrologic engineering management plan (HEMP) for Lake Mendocino Forecast-informed Reservoir Operation (FIRO) evaluation of water control plan alternatives within the final viability assessment (FVA)

Version 3.0, August 1, 2019

Summary

In 2014, Sonoma Water (SW) undertook a study to confirm the agency could manage Lake Mendocino storage more efficiently for authorized project purposes by integrating reservoir inflow forecasts explicitly in release schedule decision making. That study—which was referred to as the preliminary viability assessment (PVA)—confirmed SW could increase water supply benefit without adversely affecting the flood risk reduction capability if forecast-informed reservoir operation (FIRO) procedures were used. The US Army Corps of Engineers (USACE), which is responsible for flood operation of Lake Mendocino, agreed with the finding and subsequently approved SW's request for a major deviation from the Lake Mendocino water control plan (WCP). This temporary deviation permitted SW greater flexibility in managing Lake Mendocino storage, pending additional investigation that would support incorporation of FIRO procedures in a formal revision of the WCP.

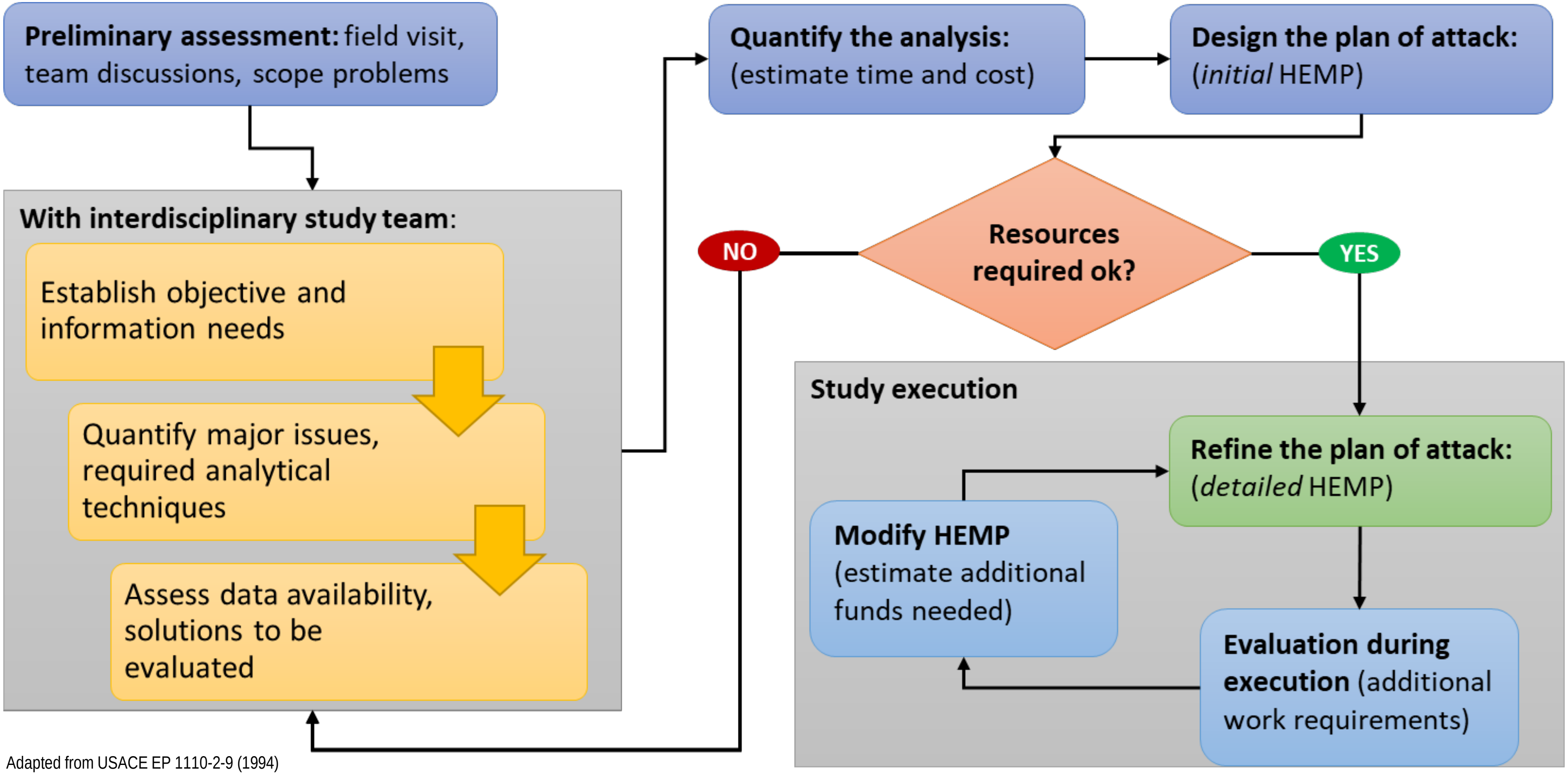
The PVA evaluated candidate FIRO strategies in a reconnaissance-level technical study, confirming viability of FIRO in concept. However, the PVA did not recommend a single specific strategy for integrating FIRO into a future WCP. That task is to be completed in a subsequent planning study—the full viability assessment (FVA). The objective of the FVA is to identify, through appropriate detailed technical analyses and other considerations, the best FIRO strategy for Lake Mendocino, along with the manner in which that can be implemented in real-time operation by SW and USACE and the WCP changes necessary to permit that change permanently. The FVA will also evaluate potential adaptive strategies that would allow operators to utilize new technology and improved forecast skill as it becomes available in the future.

The FVA is managed by the Lake Mendocino FIRO steering committee (SC), which identified necessary technical studies. to be consistent with USACE guidance for conduct of similar technical studies The SC prepared this hydrologic engineering management plan (HEMP) as …*a technical outline of the hydrologic engineering studies necessary to formulate a solution to a water resources problem* (*Engineering Pamphlet 1110-2-9*).

This HEMP includes the following:

1. Statement of objective and overview of technical study process to provide information needed for the FVA.
2. Specification of requirements for the FIRO alternatives that will be considered. These are presented in Table 1, Table 2, and Table 3.
3. Identification of tasks to be completed for the technical analysis. These are presented in Table 4.
4. Identification of analysis tools and methods to be used for the study.
5. Identification of the project team members and their roles and responsibilities for conduct, review, and approval of the hydrologic engineering study. These are presented in Table 7 and Table 8.
6. Analysis schedule. This is presented in Figure 1.

HEMP DEVELOPMENT



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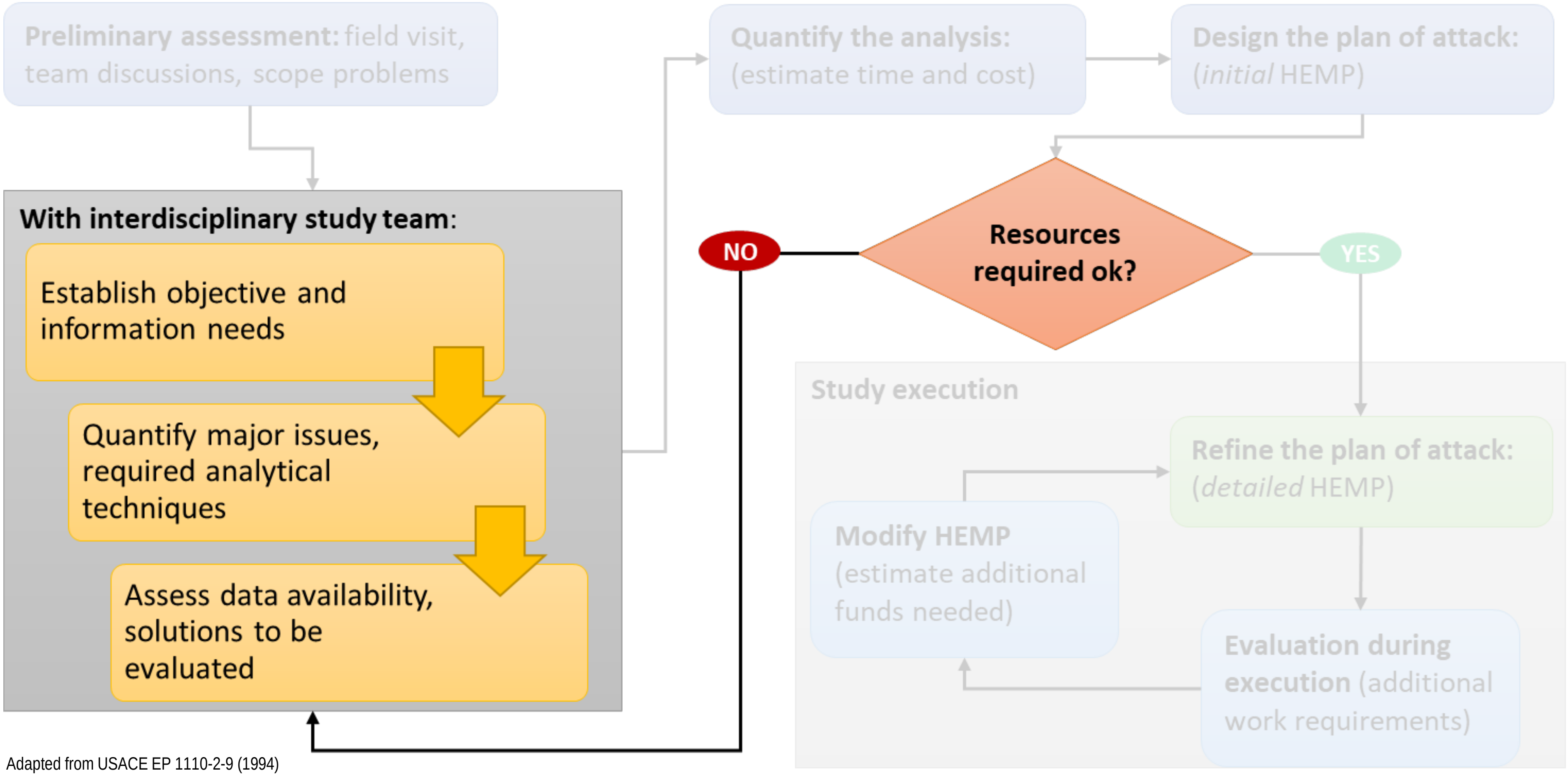

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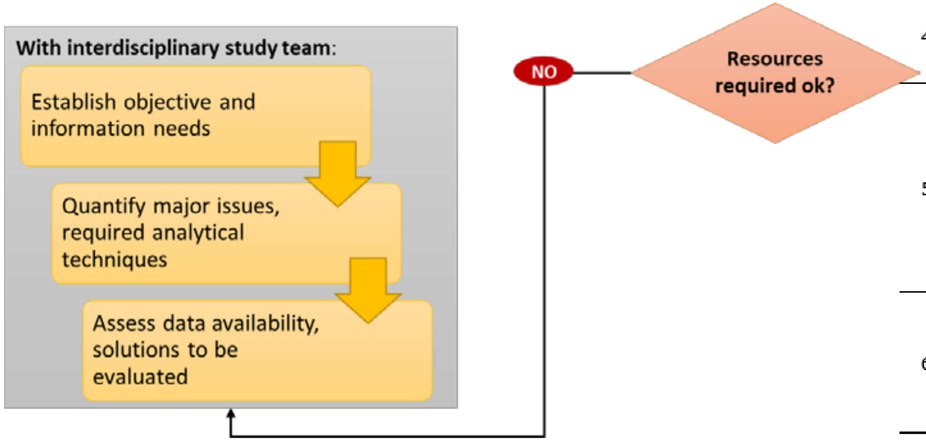

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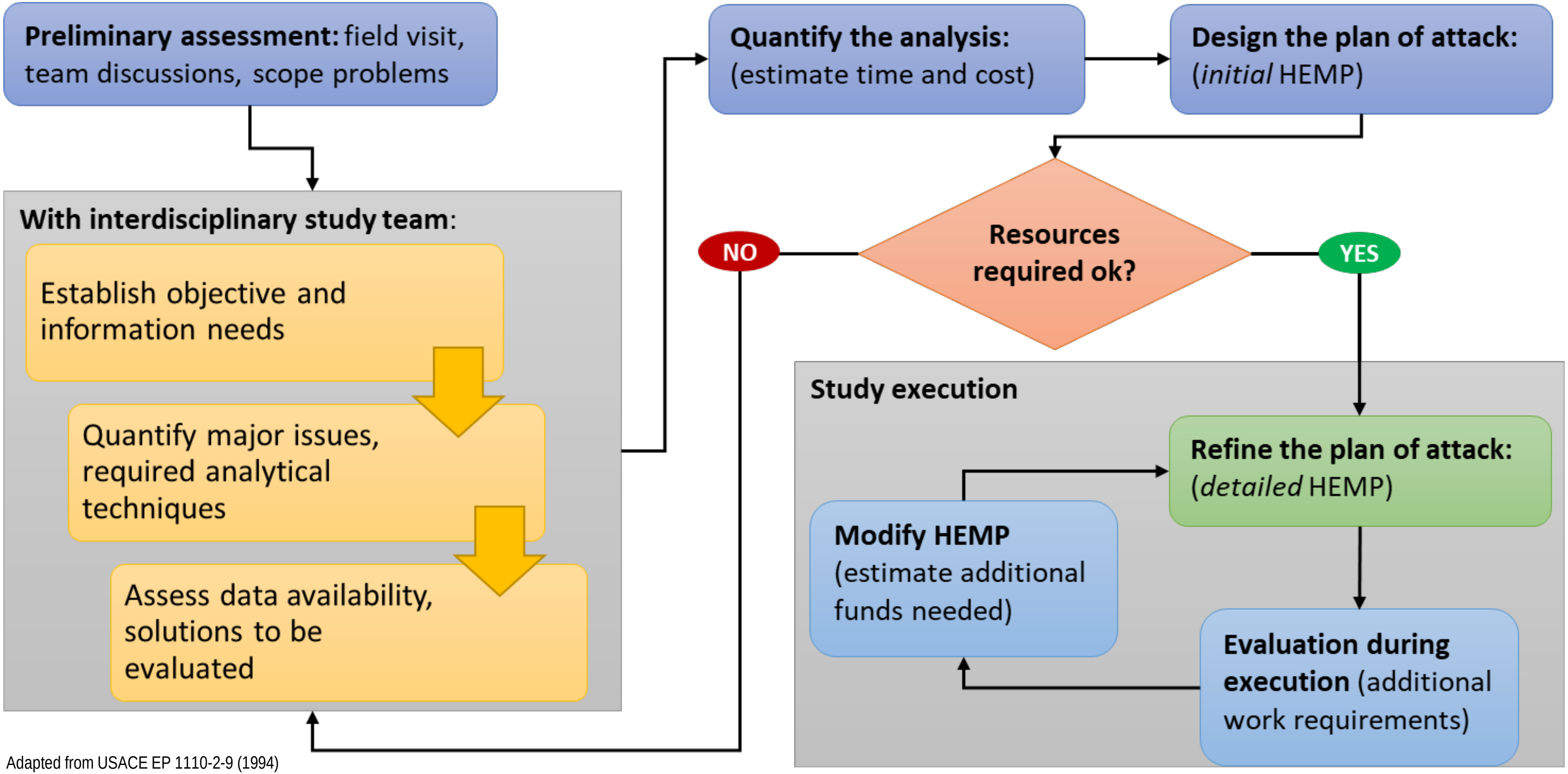

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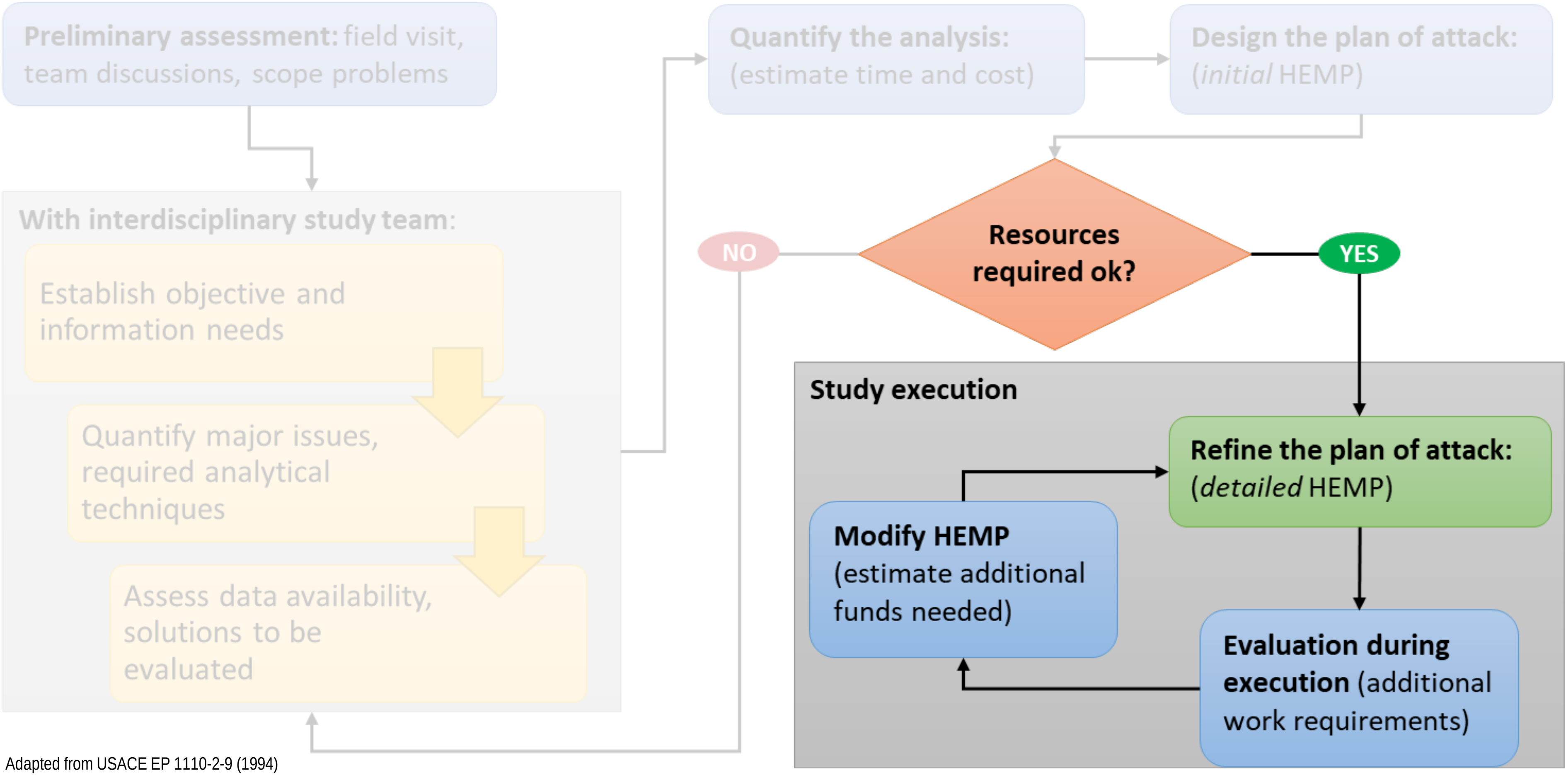

Adapted from USACE EP 1110-2-9 (1994)

LESSON LEARNED

- Start NOW!!!!
  - (Develop a HEMP ASAP)
- Expect the unexpected
  - (Things take longer than expected)
  - (You will discover errors required reanalysis/revisions)
- Coordination is KEY
  - (Make objectives and analysis constraints clear to PDT)
- Consider how the results inform the decision makers
  - (Ranking and weighting Metrics is needed for transparency and objectivity)